NEWFOUNDLAND AND LABRADOR

DEPARTMENT OF CONSUMER AFFAIRS
AND ENVIRONMENT

WATER RESOURCES
REPORT 2 - 1
GROUNDWATER SERIES

HYDROGEOLOGY
OF
THE GREAT NORTHERN PENINSULA

BY
NOLAN, WHITE & ASSOCIATES LTD.
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ABSTRACT

The hydrogeology of the Great Northern Peninsula has been studied with the exclusion of the interior portion underlain by crystalline rocks of precambrian age. This has been the first such regional study undertaken by the Department of Consumer Affairs and Environment and has been based exclusively on pre-existing data.

Three maps have been prepared to accompany this report. Surficial and bedrock geology are on two separate map sheets. The hydrogeological map displays watersheds, drilled well locations, springs and hydrostratigraphic units.

There are no major aquifers in the surficial deposits due to the general thinness of the materials and scarcity of outwash type deposits. This is especially true along the coastal zone where the need for potable water is greatest.

The entire study area is underlain by paleozoic sedimentary rock which, apart from the transported rocks, is relatively undisturbed and contains abundant carbonate sequences. Based on the limited groundwater data, the best aquifers appear to be within the St. George Group. These carbonates display varying degrees of permeability related to vugs and solution channels but in places are strongly influenced by jointing. In the Daniels Harbour area, the only area in which a significant amount of aquifer testing has been carried out, transmissibilities have been calculated to be in the order of 75,000 litres per day per metre.

Total available groundwater recharge within the study area is estimated at one million cubic metres. This is equivalent to an annual infiltration of 45 mm. These figures are, at best, rough estimates in the absence of sufficient data. In addition, available infiltration has been assumed to be 5% of the total annual precipitation. According to these values, the total groundwater withdrawal is probably less than 1% of the available.

Groundwater quality throughout the study area is generally good as is indicated by the somewhat limited chemical data. The most common chemical problems, excessive iron and colour, relate more to the aesthetic quality than to potability.

Considerably more hydrogeological data is required in order for groundwater to be properly assessed as a resource on the Great Northern Peninsula.

INTRODUCTION

GENERAL

This report was compiled by Nolan, White & Associates under assignment from the Department of Consumer Affairs and Environment, Province of Newfoundland and Labrador. As per the terms of reference for the study there was no field work carried out. The entire office study was based on available published and unpublished reports and data having any relevance to the hydrogeology of the Great Northern Peninsula.

As a continuing effort to evaluate the water resources of Newfoundland and Labrador,the Department of Consumer Affairs and Environment has initiated this first regional hydrogeological study within the province. Additional regional studies are planned as a follow-up with the intention of providing total coverage of the island eventually.

The object of this study has been to determine the physical characteristics of the major geologic units in relation to the occurrence, availability and quality of groundwater.

SCOPE OF STUDY

This report describes the physiography, the surficial and bedrock geology and the hydrogeological properties of the surficial deposits and bedrock. Maps have been prepared at a scale of 1:250,000. These display bedrock geology, surficial geology and hydrogeology with accompanying notations and unit descriptions. Groundwater chemistry data has been compiled and evaluated in the section on water quality along with a discussion on pollution and salt water intrusion.

FIGURE NO.1 : Location And Extent Of Great Northern Peninsula Hydrogeological Study.

LOCATION

The study area is located on the Great Northern Peninsula of the Island of Newfoundland. It comprises all the terrain of the coastal lowlands between Rocky Harbour, Bonne Bay to Englee, Canada Bay. It excludes areas underlain by Grenvillian basement rocks. The total area is approximately 8500 square kilometres.

POPULATION AND ECONOMY

The study area is occupied by some 23,000 inhabitants in widely scattered communities. Englee (pop. 1,500), Roddickton (1,400), St. Anthony (4,000), Port aux Choix (1,200) and Rocky Harbour (1,267) are the major centres. The principal industries are fishing, forestry, mining and government. The area has three electoral districts. The main transportation link is Highway 430 which links nearly all of the communities. Water transport is of secondary importance.

CLIMATE

The climate within the study area is sub-arctic with a mean annual temperature of near $4^{o}C$ at Rocky Harbour and approaches $1^{o}C$ at St. Anthony. The mean annual precipitation is about 900 mm with about 500 mm of this falling as rain. Snowfall is greater in the north than south.

PREVIOUS WORK

No previous hydrogeological studies of this nature have been carried out on the study area. There have, however, been several studies carried out on behalf of the Provincial Department of Municipal Affairs

and Housing for community water supplies, as well as one commissioned by Newfoundland Hydro on the Strait of Belle Isle area. The Atlantic Development Board commissioned a joint survey by the Shawinigan Engineering Company Limited and James F. MacLaren Limited on all of Newfoundland and Labrador.

Stream flow data was supplied by Environment Canada - Inland waters Branch. Precipitation data was supplied by Envirnoment Canada - Atmospheric Environment Service.

Geologic information was taken from many of the published reports and open files of the Department of Mines and Energy. Water well and municipal supply data was supplied by the Department of Environment and Consumer Affairs.

ACKNOWLEDGEMENTS

This report has been compiled by members of the staff of Nolan, White and Associates, in consultation with W. Ullah and J. Robinson, Department of Consumer Affairs and Environment, province of Newfoundland and Labrador. It was carried out under the supervision of F. Nolan. J. DeGrace, C. Miles and H. LeBlanc compiled much of the background data and research. Maps, drawings and graphs were drafted by W. Fitzgerald and F. Garland, and the manuscript was typed by D. Cameron and K. Rushton. Also most helpful in providing data were N. Mercer, provincial Department of Mines and Energy, N. Parsons, provincial Department of Municipal Affairs and Housing, D. Butt, Newfoundland and Labrador Hydro, W. Lush, Federal Department of Public Works, and D. Snow of Environment Canada (Inland Waters).

TERRAIN & GEOMORPHOLOGY

The terrain and geomorphology of the study area were described respectively by Twenhofel and MacClintock (1940) and MacClintock and Twenhofel (1940). Subsequent work by D.R. Grant of the Geological Survey of Canada led to much more specific geomorphic descriptions of the Great Northern Peninsula.

The physiographic subdivisions of the Great Northern Peninsula correspond closely to the geologic subdivisions. The area underlain by Grenville basement rocks is known generally as the Long Range Mountains and was included by Twenhofel and MacClintock (1940) in the "Atlantic Upland", which comprises much of central and eastern Newfoundland. The mountains rise to elevations of 600-750 m and define a peneplain at around 600 m (ibid.). The "Serpentine Hills" near St. Anthony are underlain by the transported St. Anthony Complex; and the Highlands of St. John, which range in elevation from 250-300 m, are underlain by resistant Cambrian sedimentary rocks. Extending around the coastal areas from Canada Bay to Bonne Bay is the West Coast Lowland, underlain by platformal sedimentary rocks and ranging in elevation from 20-120 m. Vegetation is generally scrubby and sparse, except in sheltered areas on the west coast lowland. Thin peat deposits are widespread on the lowland between Bonne Bay and Port Saunders. Rocks of the coastal lowland are, for the most part, thickly buried beneath marine and glacial deposits, but, in highland areas, rock is everywhere at or near the surface.

The entire study area has undergone Pleistocene glaciation, and, in most areas, only the most recent (Wisconsin) glacial advance is evident. Grant (1977), however, found evidence for three periods of glaciation in

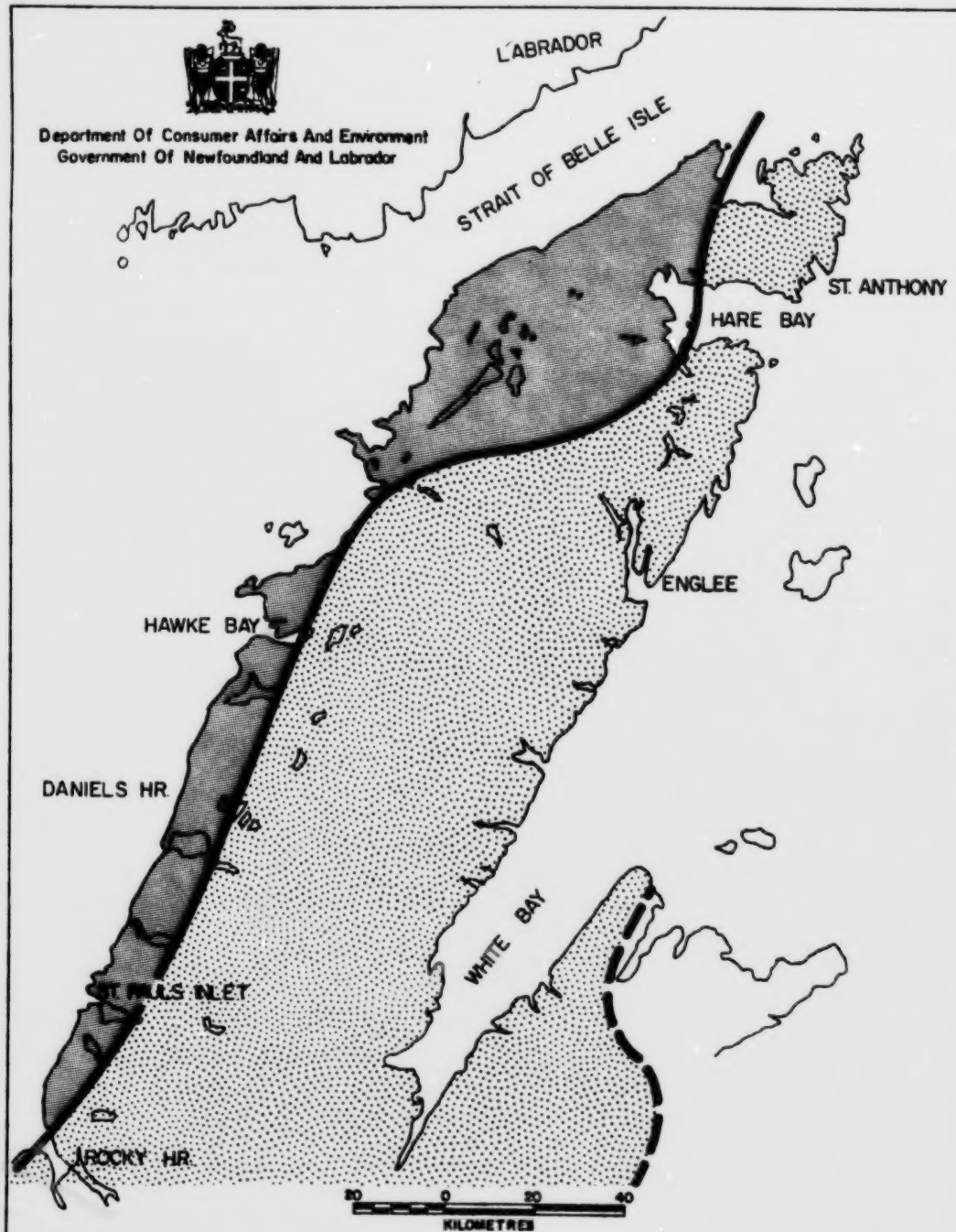


FIGURE NO: 2 Physiographic Subdivision of the Great North Peninsula, Nfld.

St. Lawrence Lowland (Newfoundland Coastal Plain)

Newfoundland Highlands (Long Range Mountains)

the presence of three distinct degrees of weathering in the higher glaciated terrains. "The significance of these weathering zones lies in the fact that they manifest the (long) time intervals that have elapsed since they were glaciated" (ibid., p. 461). A lower, freshly-glaciated zone was distinguished; then a middle, higher zone of weathered glacial bedrock landforms; and finally an upper zone of broken bedrock devoid of glacial features except rotted erratics. Populated areas on the Great Northern Peninsula are all in lowland regions and were affected by all three glacial episodes. Only the latest of these, the Wisconsin advance, can be described in any detail.

Glacial ice movement during most of the Wisconsin advance was outward in all directions from a centre on the Long Range Mountains. While the Long Range Mountains icecap may have been connected to ice sheets in Labrador or in central Newfoundland, it was independent at least during late glacial times (Grant, 1974, 1977). Valley glaciers flowing from the Long Range Mountains icecap carved the spectacular gorges now occupied by Western Brook Pond and St. Paul's Inlet.

Grant (1969a) interpreted a four-phase Wisconsin glacial sequence for the Great Northern Peninsula:

1. Ice from Labrador advanced southeastward over the west coast lowland, and up the flanks of the Long Range Mountains, to elevations of around 300 metres. A shelly glacial drift related to this advance is widespread, and the direction and limits of the advance are indicated by well-defined uni-directional glacial striae and roches mountonnees. Rare eskers in the Pistolet Bay area may have originated with this advance.

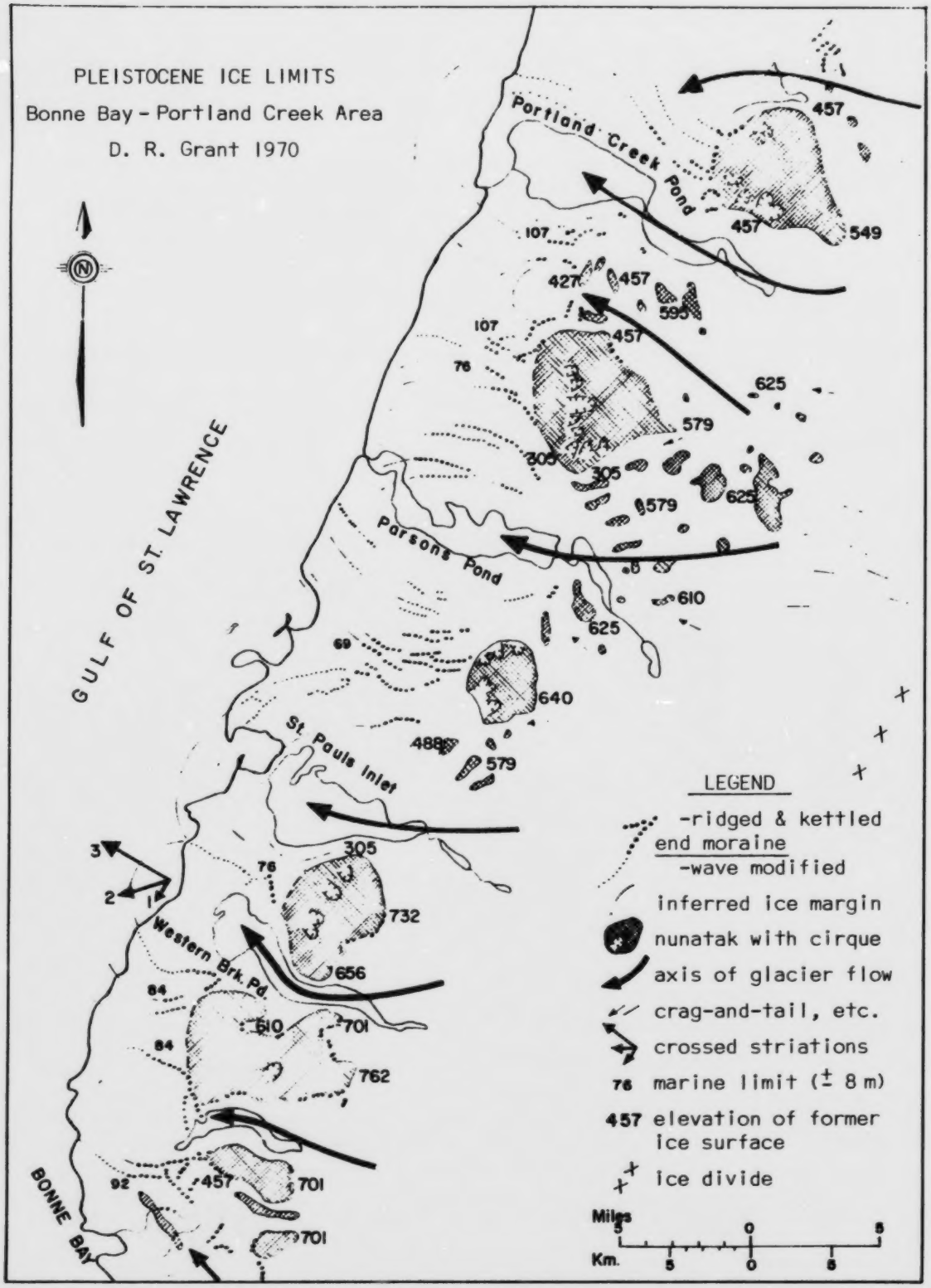

PLEISTOCENE ICE LIMITS
Bonne Bay - Portland Creek Area
D. R. Grant 1970
GULF OF ST. LAWRENCE
Portland Creek Pond
Parsons Pond
St Pauls Inlet
Western Brk. Pd.
BONNE BAY
LEGEND
-ridged & kettled end moraine
-wave modified
inferred ice margin
nunatak with cirque
axis of glacier flow
crag-and-tail, etc.
crossed striations
76 marine limit (± 8 m)
457 elevation of former ice surface
ice divide
Miles
Km.

FIGURE NO: 3

2. Subsequent retreat resulted in a bay enlarging progressively northeastward up the Strait of Belle Isle by melting which proceeded inland to an ice divide near Hare Bay. The sea at this time was about 100 m higher than at present, as indicated by the widespread presence of De Geer moraines. These moraines form parallel ridges trending north from the Long Range Mountains on the west coast lowland, and are best seen in lakes as "bouldery spits, islands, and shoals up to ½ mile (800 m) long, 500 feet (150 m) apart, and less than 25 feet (8 m) high .... the spacing and extent of De Geer Moraines suggest that the retreat lasted 300 years at most" (Grant, 1969a, p. 124).

3. As the lowland ice sheet was retreating, ice from the Long Range Mountains advanced northward and westward. To the north, the ice advanced into the sea, fluting and drumlinizing the surficial deposits on north-trending axis. An end moraine related to this advance occurs north of Ten Mile Lake and has a maximum age of 10,9000 years. By that time sea level had fallen to about 60 m above the present level. The Ten Mile Lake moraine system is 52 km long with several kettled ridges and a relief of 15-45 m. The northward moving ice may have merged with the retreating ice of phase 2 in the Hare Bay area as marked by the southern limit of De Geer moraines.

At the same time, ice from the Long Range Mountains was flowing westwards into the Gulf of St. Lawrence (Grant, 1969b). This moving ice carved glacial valleys in Western Brook Pond, St. Paul's Inlet, Parsons Pond and Portland Creek Pond, and resulted in cirques being excavated in higher ground between the valleys. Ridged and kettled

end moraines relating to this advance have been extensively modified by wave action.

4. The final retreat of the ice sheet, centred on the Long Range Mountains, was marked by active ice flow as shown by lineated drift, crag-and-tail and roches moutonnees. Retreat did not culminate on the crest of the Long Range, but rather at an ice divide many metres lower near the median line of the plateau.

At the present time, the Great Northern Peninsula is emerging due to post-glacial rebound. Sea level has dropped in the north by 60 m since the Ten Mile Lake re-advance of 10,900 years ago. In the south around Bonne Bay, no present net change is evident and further south, in the St. George's Bay area, the coastline is submerging. Thus Grant (1972) postulated a pivotal line extending across the Great Northern Peninsula in the Bonne Bay area.

DRAINAGE

Drainage within the area is in the somewhat haphazard nature that is typical of glaciated terrain. There are thirty river and brook basins within the study area, ranging from about 32 km^2 to 945 km^2. Drainage patterns are generally dendritic in nature, except in the northern sections where the water courses commonly follow the northeast trend of the bedrock. The normally-very fine-grained glacial and marine soils and flat terrain have given rise to an extensive network of bogs and swampy land throughout the area.

Solution channels in limestone have resulted in numerous underground drainage systems in the Daniel's Harbour area and also in an area

to the west and south of Hare Bay. This "karst" topography, near Hare Bay, has, according to Grant, been modified somewhat by glaciation:

> " .... numerous solution cavaties occurring over a north-south zone west of Roddickton and Main Brook, of which the larger ones have been unroofed by the overriding glaciers."

HYDROLOGY

GENERAL

Generally, little hydrological information is available for much of the Northern Peninsula; certainly there is little information available on which to base a hydrologic budget for the area. Precipitation values at the five climatic stations in the Northern Peninsula (see Figures 8 to 15, Appendix B) are comparable or slightly lower than other locations in Eastern Canada with a Maritime climate. Generally, July through to September are the months of greatest precipitation, although, in the late fall and winter, similar or slightly higher precipitation values may be found in some stations. On the west coast of the Northern Peninsula, fall and winter precipitation values are relatively constant, usually showing little variation, while stations on the east coast are seen to be more variable. The amount of monthly precipitation that falls as snow is significantly larger than most climatic stations in Eastern Canada, especially those near the coast. Not only is the amount of snow greater, but the period when significant precipitation falls as snow is longer.

As one might expect, the late winter season shifts the peak period of yearly discharge into early summer, as opposed to early or late spring.

Stream discharge data for three stations are shown in Appendix B. Minimum discharges occur in the winter months and reflect freeze-up conditions on these rivers. Baseflow conditions generally occur during late summer or early fall. The discharge values for these periods would appear, based on the precipitation measured, to be composed principally of surface runoff and overland flow with groundwater baseflow having only minor influence on stream discharge. In some cases, this lack of groundwater influence on baseflow may be indicative of bedrock that has little storage capacity or is dependent upon secondary permeability to provide storage capability.

One of the major factors in determining a hydrologic budget for a particular area is the evapotranspiration component of the budget equation. Generally, evapotranspiration is determined on the basis of meteorological information, although, in some cases, other methods have been used. Regardless, there is just not sufficient information available for any of the watersheds in the Northern Peninsula to allow an estimate of evapotranspiration rates. Given the location, climatic conditions and vegetation in the study area, one could expect lower evapotranspiration rates than most other areas in Eastern Canada; however, just what these rates would be is not known.

A list of watersheds within the Northern Peninsula study area, whose areas are greater than 30 km^2, is provided in Table 1. As well, descriptions of the major watersheds within the Northern Peninsula are given in the following section and a graphic presentation is included with the Hydrogeological map accompanying this report. The descriptions are intended to help familiarize the reader with some of the basic features which control the hydrology of watersheds in this area.

TABLE NO. 1

RIVER BASIN ANALYSIS - GREAT NORTHERN PENINSULA
(Basins greater than 30 km^2)

RIVER	km^2	REMARKS
Bakers Brook	97	
Western Brook Pond	200	
St. Paul's River/Inlet	315	
Parsons Pond	353	
Portland Creek	945	
River of Ponds	872	
Torrent River	611	
East River (Hawke Bay)	93	
Port Saunders Brook	55	
Doctors Brook	73	
Castor's River	451	
Ten Mile Lake (St. Genevieve River)	317	
West River	138	
St. Barbe River	47	Possibly water from these systems interchange at one point near Green Island Cove
Green Island Brook	112	
Eddys Cove Brook	100	
No Name Brook	36	5,702,200 N 553,200 E
No Name Brook	30	5,694,400 N 543,400 E
Big Brook	196	
Boat Harbour	77	
Shallow Bay Brook	57	Large surface storage
Small Brook entering Pistolet Bay	86	
Small Brook near Raleigh	57	
Northeast Stream	35	Large surface storage
Bartletts River	40	
Milan Arm	38	
Starks Bight	24	
Irelands Brook	63	

TABLE NO. 1 (cont'd)

RIVER	km^2	REMARKS
Parker River	41	
Hare Bay Brook	143	
West Brook	117	
Internal Drainage	222	
Salmon River	664	Southwest Brook = 180 Area of internal drainage = 13
Great Inlets Harbour River	32	
Freshwater Creek	91	
Northeast Brook	211	
Roddickton Brook	36	
Beaver Brook	230	
Shoal Brook	64	
Northwest Brook	112	
Cloud Brook	504	

WATERSHED DESCRIPTIONS

Portland Creek Pond

The area of this watershed is 970 km^2. Approximately 40% of the watershed consists of coastal lowland while 60% is formed from the Long Range Mountains. Only slight topographic relief exists in the lowland area; it generally slopes south or nothwest towards Portland Creek Pond. The easterly portion is marked by a steep topographic rise and plateau area. The gentle stream gradients in the lowlands reflect the influence of the less resistant rocks of the St. George group *(8,9) and/or Table Head Formation (9,10) and also the transported Cambrian-Ordovician (4,5,6,7) aged rocks. Very steep stream gradients occur at the contact of the Long Range Mountains while less steep gradients are found in the plateau area further east. These former streams are typified by steep, narrow valleys. Approximately 20% of the watershed area consists of surface water; principally Portland Creek, Inner and Brian's Ponds, the remainder consists of irregular ponds located on the highland plateau. Swamp and bog constitue 7% of the total area, most being found in the coastal lowland. Within the coastal lowland, some lineation of ponds and streams exists in a northeast to southwest direction which is probably related to bedrock structural features.

River of Ponds

This watershed is 840 km^2 in area. Sixty percent of this watershed lies in the coastal lowland; the remaining 40% consists of the Long Range Mountain uplands. The relief within the coastal lowland is subtle with several small exceptions; topographic variation is generally less

* see Bedrock Geology Map

than 90 m. Eastward the relief dramatically increases along a broad front, defining the Long Range Mountains with its associated plateau area. Stream gradients are generally toward the northwest in both lowland and highland areas. In the coastal lowland,stream gradients are very gentle, except in areas of rapids where bedrock outcrops, indicating the influence of the softer sedimentary and related rocks of the Ordovician-St. George group and Table Head formation*(9,10), as well as the Cambrian sedimentary formations. The stream gradients become very steep upon encountering the highly resistant Helikian foliated granites of the Long Range Complex (1) and the streams are enclosed by narrow valleys. Surface water comprises 35% of the watershed, most of this being found in Flat, Eastern Blue and Western Blue Ponds, and also River of Ponds and Michel Lakes; the remainder is distributed about equally in lowland and highland areas. Swamps and bogs constitute about 9% of the total area; most is found in the coastal lowland. Some northeast to southwest lineation of ponds, streams and local topography does appear to exist, although not as well pronounced as in other watersheds. Presumably these lineations are related to bedrock structural features such as faults.

Torrent River

This watershed is 612 km^2 in area. About 35% of the watershed lies within the coastal lowlands, the remaining 65% within the Long Range Mountain uplands. Stream gradients are gentle,both in the southwest corner and easterly portions of the watershed; elsewhere in the lowlands, the gradients are moderately steep. This probably results from the north-east-southwest and north-northeast-south-southwest trending faults that

* see Geology Bedrock Map

occur in the Ordovician sedimentary and the Cambrian sedimentary and volcanic rocks. As in other areas, the gradient steepens along the contact with the Helikian foliated and metamorphosed granites; however, unlike areas previously discussed, the stream valleys are not generally steep and narrow. Topographic elevation within the uplands are somewhat reduced over those further south. Approximately 17% of the watershed area consists of surface water, much of it in small, interconnected ponds in the highlands; the only large suface water body is Western Brook Pond. Barren land with little or no vegetation, and consisting generally of bedrock exposures, comprises 50% of the watershed area, while swamps and bogs constitute 8% of the watershed. Streams, ponds and local topography show a northeast-southwest lineation, presumably structurally controlled; in addition, some ponds and streams show a north-south lineation which would also parallel structural trends.

Castor's River

This watershed is 403-529 km^2 in area. The coastal lowland constitutes about 60% of the watershed, while 40% lies within the Long Range Mountain upland. In the northern lowlands, relief is lowlying to gently rolling; southward, a large topographic high is predominant. Such high relief (approximatley 2,000 feet) is atypical of the lowlands and is probably structurally controlled. The relief in the uplands is more modified and irregular than other areas further south. Although some contrast in relief exists in the aforementioned areas, it is not nearly as well defined as in other areas. Stream gradients in the northern lowlands are gently inclined while, in the southern lowlands, they are moderately steep. Only

along the contact between the Ordovician sedimentary and the Cambrian sedimentary plus volcanic rocks of the lowland and the foliated, Helikian granites are the gradients steeper. Within the uplands, stream gradients are variable and at best are only moderately steep. Bodies of surface water within the uplands represent about 10% of the watershed area and are located in the Long Range Mountains. The largest body of surface water is Leg Pond. Of the entire watershed area, 15% consists of barren land where bedrock is exposed, while about 5% consists of swamps and bogs. Structurally controlled lineations can be defined for some streams and ponds, however, they are generally confined to areas underlain by foliated granite.

Cloud Brook

The area of this watershed is 504-521 km^2. The entire watershed lies within the Long Range Mountains. The relief is quite rugged and variable, especially in the eastern portion of the watershed; in the most westerly portion, it becomes less variable and more typical of the plateau area. Stream gradients are usually moderately steep throughout the entire watershed, with local topographic highs controlling drainage in many areas. The entire area is underlain by Helikian foliated and metamorphosed granite, Cambrian sedimentary and volcanic rocks and Cambrian diabase dykes which account for the ruggedness of the watershed area. Approximately 10% of the waterhsed consists of surface water in generally small scattered ponds. About 25% of the watershed consists of barren exposed bedrock; approximately 10% is comprised of swamps and bogs. Indications of NE to SW lineations are exhibited by some ponds and streams in the easterly portion of the watershed; these features are probably controlled by the diabase dyke

intrusions which strike NE to SW.

Salmon River

The area of this watershed is 598-641 km^2. The entire watershed is within the coastal lowland area. The relief is very subdued throughout most of the watershed, except in the scuthernmost portion, where there is a general rise in topography to meet the Long Range Mountains. Consequently, the more pronounced drainage patterns are northwards into the Salmon River. Stream gradients throughout the watershed are only very slightly inclined with the gradients in the aforementioned southern area slightly to moderately inclined. The subtle relief and stream gradients are typical of Cambrian sedimentary and volcanic units, and also the Ordovician-St. George group and Table Head Formation (9,10). About 12% of the total watershed area consists of surface water bodies, most of it occurring in scattered small ponds. In addition, swamps and bogs comprise about 7% of the total area. Some of the ponds and streams within the portion of the watershed closest to Hare Bay show NE to SW lineation trends. These trends parallel the bedrock structural trends and are probably related.

Internal Drainage

These watersheds are found within the coastal lowland and are not externally drained by surface channels. The topography within these watersheds is flat-lying, except for some very small local highs. The stream gradients in these watersheds are very slightly inclined to virtually nonexistent. The area of surface water in these watersheds varies from 10-40%

while the area of swamp and bog varies from 2-15% of the total area.

GEOLOGY

SURFICIAL DEPOSITS

Surficial deposits range from thick and nearly continuous in the southern portions, to thin and patchy in the northern parts. For the purposes of discussion, the area will be divided into two regions on opposite sides of an imaginary line passing through Hawke Bay in an east to west direction.

South Half (Grant 1973)

This portion has a complex array of glacial and marine soils which resulted from valley glaciers off-shooting from a large piedmont glacier into a sea whose average elevation was about 100 m above present values. The glacial soils comprise extensive ground moraine and end moraines. The moraines are hummocky, with conical mounds and depressions. They are ridged and are composed of very coarse till littered with gigantic erratic boulders. Below the ancient sea level, they have been reworked and many occurrences of boulder-pavement can be found. Many are etched by shoreline terraces and ribbed with beach ridges. At lower elevations, much of the moraine is buried beneath 6 to 15 m of gravelly marine sand. Extensive bogs, generally a couple of metres thick, cover much of the marine plain.

The former submergence of the coastal areas on the Great Northern Peninsula accounts for the presence of numerous raised beaches parallel to the present shoreline, and a widespread blanket of marine sediment which

thickens seaward. South of Daniel's Harbour, these marine deposits occupy the flanks of moraines and intervening swales. They consist typically of an upper unit of 1.5-3 m of sandy gravel (boulders in places) and a lower "stony marine clay .... formed by the accumulation of debris dropped from floating ice and from the ice shelf that extended eastward from the piedmont glacier" (Grant, 1973, p. 124). In at least one area near Cow Head, this marine clay overlies a shelly marine sand deposit.

Marine sands along the Gulf of St. Lawrence have been redeposited as sand dunes in a few places, and these are the only aeolian deposits in the study area.

Occurrences of glacio-fluvial soils are rare and generally away from populated centres.

North Half (Grant 1968)

Surficial deposits are generally thin and patchy, and composed mainly of till that is occasionally lodged around bedrock projections, but which is usually concentrated as discrete moraines and drumlinoid ridges. Some reworking of the tills by wave action has taken place below elevation 100 m. Many forms of glacial construction are present in spite of the scarcity of soils. The largest and most significant is an end moraine system 32 km long with several kettled ridges and a relief of 15 to 45 m. Raised strandlines are not common and are usually recognizable below 15 m.

Several depressional features traceable as aligned bogs and rectilinear waterways are the upturned bevelled edges of gently folded beds that are progressively more disturbed to the east. Other depressional features

are the numerous solutional cavities occurring over a north-south zone west of Roddickton and Main Brook, of which the larger ones at least have been unroofed by the overriding glaciers.

BEDROCK GEOLOGY

All of the rocks in the study area are included in the Lomond tectonic-stratigraphic zone of the Newfoundland Appalachians (Williams et al., 1972, 1974). The Lomond Zone comprises the stable western platform of that orogenic belt.

The zone is underlain by a continental (Grenville) basement of gneisses and schists *(unit 1) that are exposed in broad domes or uplifted blocks, the trends of which follow the topographic axis of the Great Northern Peninsula. The Grenville basement rocks are about 980 million years old and are cut by northeast-trending dyke swarms of late Precambrian age. These dykes were feeders to plateau basalts which mark the base of the sedimentary section in a few places.

The basement gneisses and plateau basalts are overlain by Cambrian and Ordovician platformal sedimentary rocks. These rocks are all indicative of shallow depositional environments, and they all thicken eastward away from the North American continental uplands. The Cambrian section comprises interbedded sandstone, limestone, dolostone and shale of the Forteau and Hawke Bay Formations (units 2,3). These units are conformably overlain by the Lower Ordovician St. George Group (unit 8) of interbedded limestone and dolostone. The St. George Group is host to sedimentary zinc deposits near Daniel's Harbour, which is the site of the only producing mine in the study area, operated by Newfoundland Zinc Mines Limited. The St. George is overlain by a thick section of massive grey

* see Bedrock Geology Map

limestone of the Table Head Formation (unit 10) which in turn grades upwards into a shaly member. Until recently, the Table Head Group was generally thought to disconformably overlie the St. George Group. While this is undoubtedly the case to the south around Port au Port, recent field work in the study area has led to the conclusion that the relationship on the Great Northern Peninsula is a conformable one.

Structurally overlying, but equivalent in age to the Cambro-Ordovician sedimentary rocks described above, are rock units which were deposited a hundred or more kilometres to the east of their present locations and which underwent westward transport by gravity sliding. The Humber Arm Group (unit 6) and Maiden Point Formation (unit 4) consist of interlayered clastic sedimentary, carbonate and volcanic units. The Cow Head Breccia (unit 5) is located to the west of the present St. George and Table Head outcrop area, but represents the eastern reef front of the Ordovician carbonate platform, its original site of deposition. The St. Anthony Complex (unit 7) of mafic and ultramafic rocks which comprise an ophiolite suite (ocean floor section) is structurally the highest of the transported rock units. Transport of all these rocks took place during Middle Ordovician times, and the Goose Tickle Formation (unit 12) of that age is, for the most part, a flysch deposit laid down to the west of the advancing allochthons.

The youngest rocks in the study area comprise the sedimentary Anguille Group of Carboniferous age. These conglomerates, sandstones and shales overlie transported rocks in the Conche area.

The Cambro-Ordovician platformal sequence is flat-lying to gently dipping, except in the east between Canada Bay and St. Anthony

where the rocks are folded into large, tight, northeast-trending upright anticlines and synclines. North of St. John Bay, the platformal rocks unconformably overlie the Grenville basement, but, to the west of the Long Range Mountains, the relationship is that of a high-angle fault. All of the transported rocks are fault-bounded, of course, and the succession of fault-bounded tectonic slices is particularly complex in the southwest around St. Paul's Inlet. Internal structure in the allochthons ranges from simple, open folds in the Hare Bay area, to complex patterns in the Gros Morne National Park area.

HYDROGEOLOGY

GENERAL

It has been mentioned earlier in this report that no field work was undertaken for this study, even though the scarcity of relevant data is well recognized. Accordingly, the data examined has been collected from every practical source and, in addition to the directly relevant groundwater data, a considerable amount of geotechnical information was reviewed. This included borehole logs and descriptions from Department of Highways projects (bridge sites mainly), transmission line route studies and data related to the proposed Strait of Belle Isle tunnel.

While there are many hundreds of shallow dug wells on the Northern Peninsula, there has never been an inventory taken. Moreover, in recent times, the tendency has been to seek other sources of supply. Since Confederation, there have been more than 30 communities serviced and communities partially serviced with systems supplying water for domestic purposes. In addition to this, drilled wells have become increasingly popular due to the availability of modern drilling equipment in western

Newfoundland. There have probably been in excess of 250 wells drilled on the Northern Peninsula during the past 15 to 20 years. An inventory of these includes a total of 187 wells, about half of which have been drilled since 1970. Due to efforts of the Department of Consumer Affairs and Environment, drilling contractors are urged to submit drilling records on all their projects throughout a given year on special forms provided by the department. Although the contractors are not at this time obliged to submit these reports, most have cooperated and done so. The value of this information, if properly recorded, cannot be overemphasized. It is hoped that the well drilling act will be passed by the House of Assembly in the near future - enabling controls to be placed on well drilling activities and assuring an even better, more complete, system of data collection.

Most communities, because of the fishing industry, were established along the coastal portion of the lowlands. Consequently, well drilling programs and geotechnical investigations have been concentrated along the coastal zone. This has resulted in a non-uniform distribution of data over the entire area.

Aquifer testing has been carried out in only a few instances throughout the entire study area. Pump testing of wells has been done for Parks Canada at the extreme southern part of the area in camp ground and day park sites. Drilled wells were also tested in the communities of Raleigh, Anchor Point, Reef's Harbour and the Strait of Belle Isle area. Borehole permeability tests and pump tests were undertaken by Teshmont Consultants at Yankee Point in a proposed tunnel shaft site. The most complete assemblage of hydrogeologic data was obtained at the site of Newfoundland Zinc Mines Limited near Daniel's Harbour. In anticipation of mine seepage/de-

watering problems, Teck Corporation commissioned a study to define the nature and magnitude of the potential problem as mining proceeded.

HYDROSTRATIGRAPHIC UNITS

A hydrostratigraphic unit consists of geological material which has unique water-transmitting and storage properties. Only interconnected or continuous interstices, pores or pore space in earth materials can serve as conduits for groundwater movement. The pore space or interstices may be classified as being either primary or secondary. Primary (or original) interstices were formed by geological processes which governed the origin of the geological units and are found in sedimentary and igneous rocks. Secondary interstices, such as joints, fractures, solution channels, and openings formed by plants and animals, were developed after the rock was formed.

In considering such units on the Northern Peninsula, one must include the surficial deposits as well as the bedrock. Aquifers in sand and gravel deposits usually originate from the development of primary pore space. These exist in sediment laid down in the period from early pleistocene to the present and may have been influenced in one way or another, by moving water. The best aquifers occur most frequently in outwash deposits-developed during the ice age period through the action of glacial meltwater. Unfortunately, such deposits are small and rare throughout the Northern Peninsula. According to Grant, the major ice fronts were destroyed by calving, leaving little opportunity for large outwash deposits to form.

Bedrock units, which may be classified as productive hydrostratigraphical units, exist within certain areas. However, it is difficult to recognize these due to the limitations of available data. Indeed, apart

from requiring a greater number of drilled well records, much more aquifer pump testing data is also required and this is extremely scarce.

Four hydrostratigraphic units are suggested, based mainly on data from drilled wells. These units are listed and displayed on the hydrogeological map in numbers 1 through 4, with number 1 being the most productive unit. Hydrostratigraphic Unit No. 1 represents areas underlain by St. George group rocks with records of yields reported to be as high as 182 litres per minute. Unit No. 2 is underlain by the Forteau Formation with yields reported as high as 230 litres per minute but with lower average yields than Unit No. 1. Unit No. 3 consists of the Maiden Point Formation, Humber Arm Group and the St. Anthony Complex, with average well yields reported to be 15 litres per minute. Unit No. 4 represents a series of rock formations and groups thought to be of low yield, less than 5 litres per minute. It includes the Basement Gneiss Complex, Table Head and Goose Tickle formations, as well as the Anguile, Green Point and St. Pauls groups.

Based on geology and records from pump testing and piezometers, nearly all bedrock aquifers within the study area are related to development of secondary interstices; most commonly joints and, to a lesser degree, faults. Due to the abundance of carbonate rocks, the presence of solution cavaties is higher in this region than in most of the remainder of the province. These cavities in carbonate rock will usually be produced by modification of pre-existing features such as joints and this is clearly displayed in the Daniel's Harbour area.

SURFICIAL DEPOSIT AQUIFERS

General

Surficial deposits throughout the study area are generally thin and discontinuous. The thin mantle of glacial drift that covers most of the

St. Lawrence Lowlands, between the coast and the Long Range Mountains, is a till which varies in composition and texture throughout the region. It varies from a silty sandy gravel till to a gravelly silty sand till. It is typically poorly sorted, a factor which contributes to its generally low permeability, with varying amounts of silt and clay size particles. Higher percentages of fine-grained material, when present, further reduce the permeability - regardless of the sorting. Numerous shallow wells have been dug in this material and, though low in yield, many are satisfactory for a single family residence. These probably yield no more than 10 L/min. and average less than 5 L/min., although no data is available to support these estimates.

The problem with the surficial deposits on the Northern Peninsula is that they are generally thin, and it is unusual to encounter adequate saturated thickness; in addition, the water table may drop a further metre or more during the summer months. This is a common complaint and one that cannot easily be dealt with, since deepening the dry well further into bedrock is costly and may not necessarily result in additional water being found. Within the drift deposits, the water table is usually higher and most satisfactorily dug wells take advantage of this fact. Such is not the case with the more pronounced ridges of beach, end moraine and glaciofluvial deposits. The ancient beach deposits are frequently well-drained due to their relatively high topography and good permeability. Many of these have been exploited by contractors seeking aggregate for construction purposes. For their purposes, however, the lower the water table, the better.

A further deterrent to the development of dug wells in the surficial deposits on the Northern Peninsula is the greater frost penetration as compared to the remainder of the island. Frost depths may reach 3 m throughout much of the area and, in the case of shallow wells, the yield may, as a

consequence, be diminished. Supply lines from wells, or surface water, may become frozen and damaged due to frost action, especially where thin overburden has prevented adequate burial. These conditions are typical of those encountered in the Sandy Cove area where overburden is thin and some ancient beach deposits exist.

Screened water wells do not exist in the study area. However, efforts were made in 1977 to develop a groundwater source of supply for a day park area within Gros Morne National Park. Two well points were put down in a fine-grained beach deposit at Shallow Bay. These test holes were located a few hundred feet from the present shoreline and gave encouraging results in respect to yield. Unfortunately, the water quality was poor due to the abundance of boggy terrain within the region combined with the fact that the aquifer was quite shallow (2 to 5 m in depth). Elsewhere on the Northern Peninsula, similar conditions may prevail since poor surface drainage is common throughout much of the St. Lawrence Lowland and boggy terrain is widespread. The quality problems most commonly associated with these conditions are low pH, high color and high iron content.

Glacial Drift

The glacial drift that thinly covers most of the study area varies in composition, but is essentially a till which, near the coastal region and throughout most of the lowlands, is high in fines and well-graded. Permeabilities in this material can be considered as being low and probably range from 10^{-2} to 10^{-8} cm/sec. Satisfactory dug wells are possible in this material so long as low yields are expected and usage is limited to single family units. Based on experience from other parts of the province, yields may vary from 2 to 10 L/min. In cases where lenses or coarser material are present, particularly if the till has been water-modified, anomalous yields of 10 to 20 L/min. might be realized and, in even rarer instances, greater

than 20 L/min. These values are unsupported estimates and based on experience of the writer elsewhere in the province where tests have been carried out on shallow wells in glacial drift.

Raised Beaches

Numerous raised beaches have been identified by Grant and others in their studies on the geomorphology and glacial history of the Great Northern Peninsula. The majority of these deposits are within a mile of the present coastline and therefore many are near villages. These deposits are usually lenticular and crescent-shape and roughly parallel to the present coastline. A number of such deposits occur along the Strait of Belle Isle coastal strip between Forresters Point and Eddy's Cove. The extensive beach development suggests a slowdown in crustal unwarping which hitherto had been too rapid to allow much beach development at higher elevations, further inland. These deposits consist of material grading from fine sand to coarse gravel and boulders. However, saturated thicknesses tend to be low and the areal extent of the deposits is limited. They represent potential aquifers of high permeability and limited storage capacity, (due to low saturated thickness); unless naturally or artifically recharged, they cannot satisfy heavy demand from communities or industry. Permeabilities may range from a high of 10^{2} to a low of 10^{-3} cm/sec within these deposits. Yields greater than 500 L/min, from drilled wells in these permeable surficial deposits, may be indicated by short term pump tests. Long term pumping tests, though, would demonstrate the limitations of many of these aquifers in maintaining a high yield for prolonged periods.

Glacial Outwash

Deposits of glaciofluvial sand and gravel are surprisingly rare within the study area as mentioned earlier. Some of the terminal moraines between Bonne Bay and Hawkes Bay contain some washed sand and gravel. This

is especially true along the border where two such moraines join, eg. between St. Paul's Inlet and Parson's Pond. These deposits, which are generally several kilometres inland, form from streams of meltwater travelling along this border zone. Where such deposits do occur, they are unfortunately relatively high and well drained and, therefore, unsuitable as aquifers. According to Grant (personal communication), between Eddy's Cove and Hawke Bay, an end moraine deposit contains 5 to 6 metres of gravel underlain by mud. The gravel is, unfortunately, dry.

From an earlier study by Nolan, White and Associates, the large end moraine at Ten Mile Lake had been identified from air photos as a potential source of sand and gravel. The hydrogeologic potential was also felt to be good if sand and gravel were deep enough. More recently, however, Van derVeer has examined this material in a recent road cut and has described it as being high in silt and clay.

Some small deposits of glaciofluvial material exist but, as stated earlier, these are inland from populated areas. Where saturated thicknesses are adequate, these deposits may enable high yield wells to be developed in the order of 500 L/min. or even better. The storage capacity and recharge characteristics would have to be carefully assessed in evaluating the long term yield of any wells in such deposits of limited size.

BEDROCK HYDROGEOLOGY

General

The study area within the Great Northern Peninsula is somewhat unique, relative to the rest of the province, since it contains the greatest assemblage of carbonate rocks within the province. Karst topography and

solution cavities are found in some areas and affect surface water drainage patterns.

Drilled wells in the various rock formations of the study area usually produce sufficient water to supply a single family residence, i.e. 3 to 10 L/min., and it is rare for wells to produce much less or to be considered as dry holes. In spite of this, most of the wells drilled generally have low yield.

Recorded yields are mostly based on drillers' reports, along with a handful of results from pumping tests and from some geotechnical projects which had reliable field supervision. Since the drillers' reports are mostly based on very short term bailing or blowing, the results are not terribly reliable. Nevertheless, the statistics should be given some credence, especially where the frequency of drilled wells is high.

In all drilled wells reported, it is thought that the water-producing zones are from either (or both) of two sources: 1)fissures and 2)solution cavities. In the case of fractures such as joints, there is a relationship between the average depth of a well (i.e. bedrock penetration) and the permeability. Figure No. 4 has been prepared to illustrate this relationship. The results are somewhat typical of bedrock wells in the Atlantic Provinces where yields are mainly fracture dependent. Most of the deep wells are of low yield, whereas the high yield wells average less than 50 m in depth. The tendency is, of course, to continue drilling until sufficient water is found. If, on the other hand, high yield is achieved at shallow depth, then drilling is terminated quickly. The economics of this situation are obvious since all drilling contractors presently operating

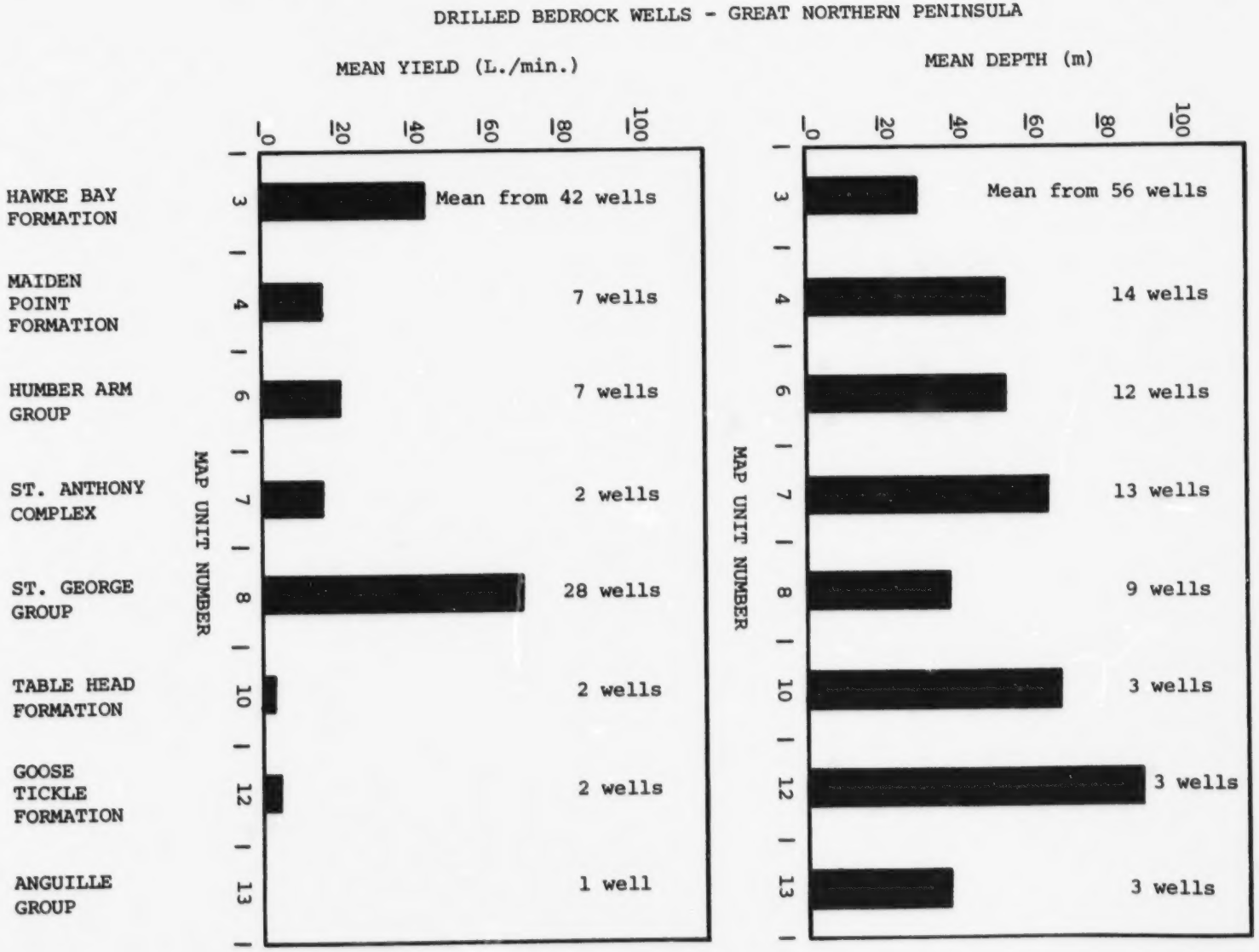

DRILLED BEDROCK WELLS - GREAT NORTHERN PENINSULA
MEAN YIELD (L./min.)
MEAN DEPTH (m)
0
20
40
60
80
100
HAWKE BAY FORMATION
MAIDEN POINT FORMATION
HUMBER ARM GROUP
ST. ANTHONY COMPLEX
ST. GEORGE GROUP
TABLE HEAD FORMATION
GOOSE TICKLE FORMATION
ANGUILLE GROUP
MAP UNIT NUMBER
3
4
6
7
8
10
12
13
Mean from 42 wells
7 wells
7 wells
2 wells
28 wells
2 wells
2 wells
1 well
Mean from 56 wells
14 wells
12 wells
13 wells
9 wells
3 wells
3 wells
3 wells

FIGURE 4

in the province charge on a price-per-foot basis.

St. George Group

This group of sedimentary rocks is the most productive within the study area and appears to contain some of the best bedrock aquifers in the entire province. From these wells, the range in yields is approximately 180 L/min. with minimum and maximum yields of 2.3 L/min. and 182 L/min. respectively. The mean depth of these wells is 39 m. which is considerably less than the overall study area mean depth of 45 to 50 m. It is within this sequence of rocks that the karst topography and mineral deposits occur at Daniel's Harbour. The same group is present further north on the peninsula in a north-trending band to the west and south of Hare Bay. Karst topography and internal drainage typifies this northernmost band of carbonates. This is not to say that wells drilled in the St. George Group are guaranteed producers. Drilled wells in the Community of Main Brook were very poor producers at less than 3 L/min.

Hawke Bay Formation

Drilled wells in this formation in the Hawke Bay area and northward are reported (drillers' log) to have relatively high yields. Based on forty-two wells reported, the mean yield is 45 L/min. with a range from 0.0 to 227 L/min. Total depth was reported for fifty-six wells which range from 4.6 to 93 m with the mean being 30 m. Compared to drilled wells in bedrock throughout most of the province, these wells are considerably above average which is somewhere in the range of 0.5 to 10 L/min. (personal evaluation by F. Nolan)

Humber Arm Group

These rocks have considerably less potential as a hydrostratigraphic unit than the older St. George Group. Based on seven reported yields, the mean yield is 20 L/min., the range being 91 L/min. with a minimum of 0.0 L/min. and a maximum of 91 L/min. Statistically, these values may be questionable, since the size of the sample, (i.e. seven reports) is not very large. Compared to the drilled wells in the study area, and based on the existing well information, yields from the Humber Arm Group are average or slightly higher. The mean depth, for wells in this group, is 54 m and is based on information from twelve wells.

Maiden Point Formation

This is composed mainly of greywacke, slate, conglomerate and minor limestone, and has a mean yield of 17 L/min., based on seven reported wells. The range is from 9 to 27 L/min. The mean depth as determined from fourteen reports is 54 m. These results are somewhat typical when one considers average yield and depth throughout the province as a whole.

Other Bedrock Units

These have not been adequately tested to provide any statistical data on aquifer yield. Yields from only two wells were reported from the Table Head Formation (limestone); both, however, were identical at 2.3 L/min. These yields are very low and any error in estimate on the part of the driller will tend to affect the mean value significantly. They are well below average for the province and are almost in the category of being "dry

holes". When such low yields are encountered, there is a tendency to drill deeper in an attempt to intersect additional water-bearing fractures and, as earlier stated, the mean depths of low-producing wells tend to be greater. The mean depth of wells in the Table Head Formation is 69 m based on three reports with a minimum of 57 m and maximum of 91 m. The Goose Tickle Formation (siltstone and shale) yielded 4.5 L/min. from each of two wells. The St. Anthony Complex, which contains volcanic and metomorphic rocks, has given wide variation in yield results from two reports. They were 4.5 and 27.2 L/min.

DANIEL'S HARBOUR - SPECIAL STUDY AREA

INTRODUCTION

In 1973, Teck Corporation, who own and operate the Daniel's Harbour Zinc Mine, requested that Acres Consulting Services Limited carry out a hydrogeologic site investigation for the new mine. Hydrogeologically, it was the most important study in the entire Northern Peninsula. The purposes were a) assessment of groundwater influx to the mine during construction; b) to estimate the nature of the groundwater flow regime in the ore zone during production; and c) to determine the most effective control method for handling these flows during construction and operation. Prior work including diamond drilling with available core and drillers' logs provided considerable aid to the hydrogeologic study.

Daniel's Harbour is situated on the western side of the Northern Peninsula, boarding on the Gulf of St. Lawrence, and is located approximately twenty miles north of Gros Morne National Park. The study area/mine area involved is positioned seven miles northeast of Daniel's Harbour, about six

miles from the west flank of the Long Range Mountains (see Hydrogeological Map).

The study area lies within a broad coastal zone about 107 to 137 m above mean sea level. The absence of strong relief is reflected by the lowlying, marshy conditions that predominate. The Mike-Zinc-Lead Lake system lies north of the study area; the lakes are generally shallow with depths usually less than several metres. To the immediate west is a small topographic rise, approximately 30 m above the surrounding land surface. Directly east of the study area are Trout and Spring Lakes which drain independently to the southeast. There is apparently no surface drainage outlet for the Mike-Zinc-Lead Lake system, although drainage in the area is towards the southeast.

GEOLOGY

General Geology

The geologic sequence consists of over 137 m of interbedded limestone, dolomite and dolomitized strata. Decreasing in depth gradationally and sequentially are the Table Head limestone; a siliceous dolomite; a dark grey dolomite; a grey to grey-tan dolomite/pseudo-breccia, which contains the ore zone; a dolomitized limestone; and the Razor limestone. The sequence has been subdivided on a lithologic basis, laterally the variations principally involve the degree of dolomitization. All units are variable in thickness with the dolomitized limestone occasionally discontinuous in cross section. All these strata are Ordovician in age, generally dipping about 5^{o} WSW. The overburden is generally thin, usually less than ten metres, consisting principally of a fine-grained till which, according

to Acres, is relatively impermeable. Bedrock cores did not indicate any single stratigraphic unit that had predominant aquifer potential. This included the vuggy dolomite/pseudo-breccia which, although porous, was not permeable due to dolomitization.

Mineralization

The sphalerite mineralization occurs as strata bound, lenticular ore bodies within the dolomite/pseudo-breccia. In this study area, the main ore body is intersected between a depth of approximately 85 to 120 m; in places, it is about 30 m in thickness.

Structural Features

According to Acres, the hydrogeologically important structural elements are related to strong monoclinal folding that occurs within the Ordovician sequence. The folding is responsible for the outcrop of the dolomite/pseudo-breccia and Razor limestone in the area of Lead Lake. Two folding related joint sets exist in the area; the major set strikes N40^{o}E, while the minor set strikes N120^{o}E; both are nearly vertical in dip. As expected, the jointing frequency is considerably greater near the fold axis. These joint sets, and solution enlargement of joint sets, appear to play a significant role in groundwater movement. Due to their vertical attitude, test drilling has provided little information on the later joint spacing. Faulting in the area, based on the test drilling, is apparently minor and of a local nature. Consequently, it would appear that faulting, at least compared to jointing, does not play a major role in controlling groundwater movement.

Since the mine has been in operation, the mine geologist and engineer have had an opportunity to more extensively examine seepage characteristics of the ore-producing zone. It is their opinion that relatively tight, closely spaced, sub-horizontal jointing is, to a large degree, responsible, in addition to the previously designated joint systems.

HYDROGEOLOGY

The hydrogeologic conditions existing within the study area are somewhat unique, although typical in regions of limestone bedrock. During the Acres study, no surface drainage outlet from Lead Lake was observable. In fact, water from Lead Lake was observed to migrate downward into the outcropping Razor limestone bedrock through joints and solution enlarged joints. It was estimated that up to 2300 L/min. was being lost through some individual joints exposed along the periphery of Lead Lake. The hydrologic connection between the surface water recharge source and the piezometric surface was further demonstrated in late October to early November of 1973. During this period, because of reduced precipitation, lake level dropped more than a metre; this was reflected by a drop of up to three metres in the piezometric surface between Lead and Spring Lakes. The recharge importance of the lake system for groundwater, at least in the upper portion of the stratigraphic sequence, appears unquestionable.

Data Collection

The investigation utilized static water levels available in accessible diamond drill holes, recovered bedrock core, packer tests, piezometers and pump tests to assess the complex hydrogeology in the area.

Initial mine development work produced numerous diamond drill holes within the ore zone; this enabled a map of the piezometric surface to be constructed. Consequently, a flow direction southeast from Lead Lake toward Spring and Trout Lakes was established. In addition, the strong local topographic control on groundwater movement was recognized.

Examination of available core and drilling information indicated the existence of a more permeable zone within the upper 45 to 60 m of the Ordovician sequence; this was based on poor core recovery, cavity frequency, loss of drilling fluids, etc. The upper twenty metres, based on this information, appeared to be very obviously permeable due to the jointing. In addition, the existence of a second permeable zone at depth was indicated by the vuggy nature and open fractures of the dolomitized limestone.

Several diamond drill holes were packer tested to provide an insitu estimate of the co-efficient of permeability (k) within one or more stratigraphic units. (A packer test measures the decrease or increase in pressure with time, as related to an initial pressure event, over a specific section of strata). Approximately eight holes were packer tested in three-metre intervals for the entire length; in addition, several holes were tested over larger sections, up to 30 m. Co-efficient of permeability values of 10^{-3} to 10^{-4} cm/sec for the upper 45 to 60 m of strata and 10^{-4} to 10^{-5} cm/sec for the underlying strata were obtained. Values in the order of 10^{-3} cm/sec were obtained for the upper and lower contacts of the dolomite/pseudo-breccia; in addition, values for the dolomitized limestone appeared to be high although these values were not qualified. Lateral variations in k values were not considered significant. The packer tests were

not able to provide any correlation between the co-efficient of permeability and bedrock lithology.

Numerous piezometers were installed in the study area, many situated to maximize the information obtained during the pump tests. Based on the pressure head elevations measured in the installed piezometers, Acres concluded that there was no significant upward component to the groundwater flow. These piezometers aided in determining the configuration and behaviour of the piezometric surface during subsequent pump tests.

In the study area, two very short pump tests were carried out on the same 152-mm diameter well, the first after the well was 70 m deep, the second after a depth of 119 m was reached. The first test, with 52 m of saturated siliceous dolomite, resulted in a drawdown of 10 m after pumping for twenty-four hours, at a rate of 159 L/min. With 100 m of saturated siliceous dolomite, dolomite, dolomite/pseudobreccia and ore zone; the second pump test, after pumping for twenty-two hours, at 463 L/min resulted in thirteen metres of drawdown. The piezometer drawdown data from these short tests indicated two things: a) the directions of groundwater flow were being influenced by structural (joint sets) and local topographic controls; b) a recharge boundary, probably Trout Lake, was affecting drawdown data from the southeast. Acres, using an unspecified method of drawdown data analysis, concluded that the transmissibilities for a 120-m bedrock well were in the range of 60,000 to 89,000 LPD/m.

Groundwater Movement

Based on the preceding data, it appears that groundwater movement is largely controlled by one, and quite possibly two, permeable zones. The

upper zone, lying within the first 46 to 61 m of the stratigraphic sequence is most certainly an active area of groundwater movement. Groundwater flow in this zone of high secondary permeability is in response to recharge from Lead Lake, the hydraulic gradients produced by local topography and the downward migration of precipitation recharge events. In addition, there is good evidence to indicate the existence of a second permeable zone at depth, within the dolomitized limestone. From the response of the only deep piezometer, which was located in the dolomite/-pseudo-breccia, Acres felt that significant groundwater flows were being contributed by the underlying dolomitized limestone during the second pump test. A lack of instrumentation and investigation within this unit prevents further speculation on groundwater movement in this zone. It is quite possible that it represents a significant influence on the hydrogeologic regime within the entire Ordovician sequence.

RELATIONSHIP TO THE HYDROGEOLOGY OF THE NORTHERN PENINSULA

Although the hydrogeologic investigation conducted at Daniel's Harbour deals with a very small section of the Northern Peninsula, it can be easily related in a larger sense to the hydrogeology of the Northern Peninsula by several factors, including bedrock geology, topography and structural controls on groundwater flow. The understanding of bedrock geology control on groundwater movement gained in the Daniel's Harbour study,can be applied to other areas of the Northern Peninsula where limestone, dolomitic and dolomitized bedrock occur. Similarly, the local topographic controls on the hydrogeology, as they exist in the aforementioned study, may be related to numerous areas of the Northern Peninsula

This is especially true for the broad coastal zone where moderate topographic relief has produced similar drainage conditions to those influencing the hydrogeology in the Daniel's Harbour study. In addition, the joint set structural control on groundwater movement, as demonstrated in Daniel's Harbour, may be readily applied to the carbonate rocks, elsewhere on the Northern Peninsula. Similar conditions would most likely occur in the St. George Group in the belt displaying karst topography south and west of Hare Bay.

WATER QUALITY

GROUNDWATER

Severe limitations exist in attempting to interpret the groundwater chemistry in the Northern Peninsula. These limitations result from the serious lack of groundwater chemistry data (see table) and the incomplete nature of the data thus far collected. In all areas, many more water chemistry samples will have to be collected before accurate evaluation of groundwater quality, as it relates to specific geologic groups of formations, can be made. Over 80% of the existing information does not have complete major cation and anion data; such information is absolutely essential if serious interpretation is to be attempted. Moreover there is a general lack of other necessary support data related to the wells and the geology, and this information can be critical in the interpretation of water chemistry results. In summary, the existing groundwater chemistry results are too limited and too restricted by lack of additional data to as yet permit any meaningful interpretation of the groundwater chemistry in the Northern Peninsula.

CHEMICAL ANALYSIS OF SELECTED GROUNDWATER SAMPLES FROM THE GREAT NORTHERN PENINSULA, NFLD.

LOCATION	COLOUR	P.H.	SPECIFIC CONDUCTANCE	TURBIDITY	T.D.S.	CHEMICAL CONSTITUENTS IN PARTS PER MILLION																	
						HARDNESS		TOTAL ALKALINITY AS $CaCO_3$	CALCIUM	MAGNESIUM	SODIUM	POTASSIUM	IRON	SULPHATE	CHLORIDE	FLUORIDE	NITRATE	SILICA	SUM OF CONST.	% OF SODIUM	MANGANESE	SAR	HCO_3
						NON-CARB.	TOTAL $Ca\ CO_3$																
GROUNDWATER																							
Conch	20	7.6	107				34		6.8	4.1			0.04				.80				ND		
Georges Bk. Mainbrook	30	6.7	94				38		10.4	1.9			ND				.32				ND		
Mainbrook	40	7.8	215				99		30.7	5.4			0.07				.08				ND		
Green I. Cove	10	7.9	155				69		14.3	8.0			0.08				.0				ND		
Savage Cove	5	7.6	52				3	47	1.0	0.1	12.5		0.06	5.5	28.8	.05	.09				.001		
St. Barbe S.	40	7.0	150				41	32					1.84			.03	.01				.06		
St. Barbe	70	7.5	650				250	258	47.4	32.0	51.0		1.69	19	90.0	.15	.30				.025		
St. Barbe Abe Doyle	50	7.7	505				207	246	27.9	33.1			.62				.14				.01		
New Ferolle	50	7.9	306				113		21.8	14.4			.01				.0				ND		
Perrys Spring Daniel's Hbr.	40	7.0	105				32	24	8.3				.12		22.6	.08	.08				.09		
Raleigh	135	8.3	436				184	419	54.1	10.5			2.93				.01				.481		
SURFACE WATER																							
Savage Cove	10 20	7.4	210				97	62	19.4	11.7	6.0			6.0	14.0	.05	.22				.004		
Roddickton	20	7.6	117				65	61	20.0	3.7	1.7	.4	.02	2.9	3.7	.09		.8	70.2	5.3	.01	.09	
Port Aux Choix	20	7.3	272				126	119	34.0	10.0	10.0	1.0	.02	5.1	17.4	.13		.8	157.4	14.6	.01	.39	
St. Anthony	60	6.7	49				17	14	2.4	2.7	3.6	0.3	.04	3.8	5.5	.08		2.3	29.2	40.0	.01	.38	
Winterhouse Rd Daniel's Hbr.	5	8.0	425				216	208	50.4				ND		15.4	.05	.48				ND		
Riv. Little Brk Daniel's Hbr.	30	8.0	251				119	108					0.0			ND	ND				ND		

TABLE 2

CHEMICAL ANALYSIS OF SELECTED GROUNDWATER SAMPLES FROM THE GREAT NORTHERN PENINSULA, NFLD.

LOCATION	COLOUR	P.H.	SPECIFIC CONDUCTANCE	TURBIDITY	T.D.S.	CHEMICAL CONSTITUENTS IN PARTS PER MILLION																	
						HARDNESS		TOTAL ALKALINITY AS $CaCO_3$	CALCIUM	MAGNESIUM	SODIUM	POTASSIUM	IRON	SULPHATE	CHLORIDE	FLUORIDE	NITRATE	SILICA	SUM OF CONST.	% OF SODIUM	MANGANESE	SAR	HCO_3
						NON-CARB.	TOTAL $Ca\ CO_3$																
Pond Cove	50	7.8	551				295	287	64.0	33.0		1.3	.08	6.7	25.5			2.1	324.7	12.5		.49	
Hawkes Bay	20	6.8	33.3				8.4	8.0	8.0				.22		1.4	.22	.04				.05		

TABLE 2 (cont'd)

Due to the aforementioned restrictions and limitations, only general broad and tentative comments can be made on the available groundwater chemistry analyses. Based on the St. Barbe, Raleigh, Mainbrook and New Ferolle analyses, it would appear that drilled wells in the St. George Group and/or the Table Head Formation tend to produce water of questionable quality much of the time. Four out of seven wells had iron and manganese problems with various degrees of seriousness. In addition, three of these four wells had elevated total calcium carbonate ($CaCO_3$) values, which may or may not have been objectionable to consumers, but which certainly represented higher than desirable hardness. Overall, calcium (Ca^{2+}), magnesium (Mg^{2+}) and total calcium carbonate are generally quite low, considering that limestone and dolomite bedrock underlies much of the Northern Peninsula study area.

In conclusion, and with reference to the limited existing data, it would appear that water quality problems encountered produce aesthetic, and not health-related, problems.

SURFACE WATER

Many of the problems discussed in the preceding groundwater section are also applicable to the existing surface water quality data (Table No.2). Again the lack of data prevents any meaningful assessment of the surface water quality in the Northern Peninsula study area. Although there is slightly more complete water chemistry information available on specific water samples, the problem of relating the water chemistry analysis to the geology still exists. Even though the geologic groups or formation can be readily determined in the area of a specific water chemistry analysis,

the geology will probably involve several different rock types, i.e. limestone, conglomerate, basic volcanics, etc. Consequently, the uppermost bedrock unit or surficial deposit which controls the surface water chemistry is often not known; this is a problem in attempting to interpret the existing data. It should also be borne in mind that one chemical analysis cannot rigidly define the water chemistry for that particular surface water or groundwater source. The data obtained from a specific sample can only be considered representative of the water source under the conditions that existed when the sample was collected. At other times of the year, under different conditions, significant variations may be found for particular chemical constituents; consequently, hindering interpretation.

Based on the very limited chemical data that exists, no obvious water quality problems are apparent. Iron, manganese and calcium carbonate do not appear to present problems as with some of the groundwater analyses. In addition, the nitrate values do not appear abnormally high (indicating eutrophic conditions). Differences, as well as similarities, are found in the analyses; undoubtedly the variations are attributable to bedrock geology and, to a lesser extent, surficial deposits. Consequently, comparison or interpretation of the chemical data becomes meaningless, since the geological conditions controlling the water chemistry are not well understood in relation to existing chemical information.

GROUNDWATER POLLUTION

GENERAL

Much of the Northern Peninsula, due to the thinness of overburden and the importance of fracture flow, is quite susceptible to some potential

pollutants. The following is an attempt to briefly outline potential sources of contaminations within the study area, based on a working knowledge of the surficial and bedrock geology, well construction practices, case histories, and other factors.

SOURCES OF POLLUTION

Seawater Intrusion

Seawater intrusion is a major potential problem for the Northern Peninsula because of the lowlying topography and the location of communities close to the ocean. The hydrostatic relationship based on fluid density, between the freshwater and seawater interface, is approximately described by the Ghyben-Herzberg relationship. In general terms, this relationship indicates that, for every change in the elevation of the piezometric surface above ocean level, the depth from ocean level to the freshwater-seawater interface will change by the same amount times a factor of forty. (For example, if the piezometric surface drops by one metre, the interface will rise by forty metres.) The elevation of the piezometric surface above ocean level will gradually decrease in lowlying areas as the water table dips seaward. Consequently, wells in communities located near the ocean have greater potential for encountering seawater intrusion problems since the freshwater-seawater interface will be closer to the land surface. The generally flat-lying stratigraphic units located in the Northern Peninsula's coastal lowland will provide a good connection to the ocean. Overpumpage of coastal wells will readily produce landward migration of the interface along such flat-lying units. Fortunately, the major structural trends are parallel to the coast, thus somewhat reducing the connection, due to fissures,

between the seawater and freshwater. A primary factor controlling seawater intrusion within a coastal zone will be the pumpage rate. If a well is pumped at a reasonable rate (based on pump tests, etc.), with consideration for the potential seawater intrusion problem, then this problem can be reduced, though never eliminated. To date, no reported cases of seawater intrusion exist in the Northern Peninsula, although certain potential problems exist with some drilled wells. As the number of drilled wells in coastal zones increases, it will just be a matter of time before some cases of salt water contamination are reported.

Waste Effluent

To a large extent within the study area, the waste effluent disposal facilities that will most likely affect the groundwater resource include cesspools, septic tank-disposal fields and private privies. Disposal of waste by any of these facilities is potentially hazardous due to the lack of surficial materials and the fractured nature of the bedrock throughout much of the Northern Peninsula. These disposal facilities are effective only if there is sufficient and proper overburden to provide filtration, bacteria reduction, and chemical breakdown of the effluent as it percolates downward. If these mechanisms cannot operate within the overburden, it is unlikely that they will be operable within the saturated zone where much of the flow is due to secondary permeability. Once this effluent reaches the saturated zone, it can migrate over large distances, contaminating surrounding wells.

Road Salt

Applications of road salt has, in many cases, been responsible for deterioration of water quality in shallow dug wells and improperly constructed drilled wells. The occurrence of ribbon housing development along existing roads, coupled with shallow dug wells, poor well construction and thin overburden, provide the necessary factors to create a potential problem. Any combination of these factors will aid directly or indirectly the existence of a road salt contamination problem.

Until the past few years, the amount of salt dispatched by the Department of Highways for winter use on the roads of the Northern Peninsula amounted to a few thousand tons. The present winter requirements are in the order of ten thousand tons and, as road conditions improve within the next several years, it is probable that fifteen to twenty thousand tons will be used annually.

Hydrocarbon Spills

A largely overlooked source of groundwater contamination is the small, frequent domestic spill of stove and/or furnace oil. These petroleum products are usually stored at or above ground level outside the home and often in the general vicinity of the well. These storage tanks, due to age or lack of proper maintenance, will rust out, usually releasing a sufficient quantity of petroleum product to cause significant contamination. Once again lack of surficial deposits and dominance of fracture flow will do little to interfere with downward or lateral migration of these hydrocarbons. Foresight in locating these storage tanks should significantly reduce this potential problem.

Well Construction

Lack of overburden and movement of groundwater due to secondary permeability makes proper well construction critically important. Shallow dug well construction generally lacks proper backfilling of the well, with washed gravel or coarse sand and installation of an adequate apron and cover. In recent years, drilled well construction practices have improved to counter some of the indicated problems. The use of drive shoes, proper casing techniques and pit-less well heads, have markedly reduced the susceptibility of these wells to potential pollutants. The hazard of many potential groundwater pollutants can be reduced, if not eliminated, by proper location and construction of wells.

WELL WATER POLLUTION - DOCUMENTED CASE

In the early fall of 1972, an epidemic of Shigella dysentry broke out within the St. Barbe north district of the Great Northern Peninsula. This communicable disease spread along the coast from Reef's Harbour, eastward to the St. Anthony area. Although hundreds of people were stricken, only one fatality was reported from St. Carols, a small isolated community near St. Anthony.

At Port Saunders, one of the three community drilled wells became polluted and all of the residents who were using it became sick. Coliform counts were in the order of 200, although the source of the fecal contamination could not be definitely ascertained. A chlorination system was later installed and the well was then designated as being safe again for human consumption.

The fatality at St. Carols was also attributed to drinking

water from a shallow domestic well, although the origin of the main epidemic could not be identified.

It was partly due to these unfortunate events that the provincial government stepped up efforts to have all community and public water supply systems chlorinated, regardless of the origin and indicated quality. All wells other than private individual ones must now be properly chlorinated and newly planned systems for communities, institutuions, etc. must meet with the approval of the Department of Consumer Affairs and Environment.

WATER USE & HISTORY OF DEVELOPMENT

Until comparatively recent times, the communities of the Northern Peninsula were relatively isolated due to the absence of roads or the poor conditions of the few that existed. When the highway was completed along the peninsula and joined up with the TransCanada Highway, in the late 1960's, services improved rapidly. From then on the Department of Municipal Affairs and Housing stepped up its efforts to supply a number of communities with central water supply systems. Consulting Engineering firms were commissioned to carry out investigations and studies where the need appeared greatest.

In 1970, the provincial government formed the Department of Community and Social Development whose mandate it was to assist in the social and economic development of the small non-incorporated communities throughout the province. A major effort was made to assist in the development of water supply systems for clusters of homes or in some

instances, entire communities. The original intention was to provide preliminary engineering studies, excavating equipment where necessary and materials such as pumps and pipe. The community was expected to provide a significant part of the labour, free of charge. Unfortunately, a number of such systems met with failure due to insufficient engineering, funding and supervision. Some of the systems utilized groundwater by means of drilled wells, shallow wells and springs. Today, the Water Services Division of the Department of Municipal Affairs and Housing, attends to the requirements of the non-incorporated communities, but the philosophy has changed in that fewer projects are undertaken in a given period but with more funding and engineering input, along with adherence to more conventional construction techniques. This has presumably resulted in a higher success ratio for functioning systems.

When the first wells were drilled in the early 1960's, it was considered an excursion for a drilling contractor to venture so far afield. The first contractor to drive a rig up the peninsula was Goodyear & Sons in 1963 and who at that time operated cable tool rigs only. Until recently, the distance, poor road conditions and lack of service depots had made it unattractive for well drillers. Today, all the major drilling contractors carry out assignments in the area from time to time, although because of the high mobilization costs (the closest base for a rotary rig at present is at Springdale), attempts are usually made ahead of time to line up a minimum of several wells. Within the past few years, there are as many as twenty wells per year being drilled.

Prior to the accelerated development since the late 1960's

conditions, with respect to domestic water supply, were extremely harsh in many communities. Shallow wells would often dry up in hot summers, and in severe winters, frost penetration might exceed the depth of the well. Some communities depended on springs or a communal well from which residents would haul water by bucket. The people who resided furthest from the well obviously experienced the greatest hardship and, in some cases, water had to be carried for more than a mile.

All of the larger communities on the Northern Peninsula are serviced by means of surface water supplies, (see Table No. 3) mostly from ponds, but, in a few instances, such as Hawke Bay, from rivers. There are no large scale water supply systems presently utilizing groundwater as a source. Large segments of some communities, such as Port Saunders and Anchor Point, had in the past been served by drilled wells. Elsewhere, a number of smaller communities have systems functioning from one or more drilled wells which supply the domestic water requirements. In the majority of instances where drilled wells are used by large numbers of homes, the yield of the well is relatively low (less than 50 L/min.) and the supply is barely adequate. Moreover, the systems earlier installed through the Department of Community and Social Development seldom had sufficient funding to provide for proper storage reservoirs and one or a few 450-L pressure tanks would do the job. The near absence of obvious major aquifers near the coastal areas has suppressed efforts to explore for groundwater. Add to this the high cost of test drilling, especially in the more northerly part of the peninsula, and it becomes clear why such little work in the field of groundwater development has been carried out to date.

TOWN	SOURCES	SERVED POPULATION
ROCKY HARBOUR	SURFACE	1267
DANIEL'S HARBOUR	SURFACE	580
COW HEAD	SURFACE	650
PARSONS POND	SURFACE	544
HAWKES BAY	SURFACE	600
PORT SAUNDERS	SURFACE	700
ANCHOR POINT	GROUNDWATER*	330
BIRD COVE	SURFACE	110
PORT AU CHOIX	SURFACE	1200
FLOWERS COVE	SURFACE	436
BIDE ARM	SURFACE	305
RODDICKTON	SURFACE	1400
ENGLEE	SURFACE	1500
ST. ANTHONY	SURFACE	2600

* New proposed source of supply will utilize surface water.

TABLE NO: 3 Summary of Water Systems in Incorporated Areas
Great Northern Peninsula, Newfoundland
Source of Information: National Inventory Index

COMMUNITY	SOURCE OF SUPPLY	REMARKS
BEAR COVE EAST	SURFACE	-
BEAR COVE WEST	SURFACE	-
BARR'D HARBOUR	SURFACE	-
BLUE COVE	SURFACE	quality problems
PORTLAND CREEK	SURFACE	-
EDDIES COVE EAST	SURFACE	-
BRIG BAY	SURFACE	-
BIRD COVE	SURFACE	-
EDDIES COVE WEST	SURFACE	-
FORRESTERS POINT	SURFACE	-
GREEN ISLAND BROOK	SURFACE	-
POND COVE	GROUNDWATER	-
SAVAGE COVE	SURFACE	-
ST. BARBE	GROUNDWATER	poor quality
ST. ANTHONY BIGHT	SURFACE	-
BLACK DUCK COVE	GROUNDWATER	-

TABLE NO: 4 Unincorporated Communities serviced by small water supply systems.

In addition to the above, there are areas in which small clusters of homes are serviced by a drilled well.

Approximately one third of the 900 mm of precipitation that falls annually is lost through evaporation. The remaining 600 mm is therefore available for groundwater recharge less the runoff. A negligible amount of this ends up as well water discharged for domestic or industrial purposes. Although data is not available to emphasize the point, it is probable that the total amount of groundwater withdrawn per year from all drilled wells in the study area is less than the total dewatered in the Daniel's Harbour mine in one week. Total daily withdrawal from all the drilled wells is probably less than 2 million litres.

The only industry on the Northern Peninsula which requires appreciable quantities of water is fish processing. With the exception of the Port Au Choix plant, most are small and require minimal amounts of fresh water except for sanitary purposes and ice manufacture. The processing of fish requires large volumes but this is usually achieved by means of salt water, if the harbour conditions are suitable. The fish plant at Englee uses large quantities of fresh water from a pond.

Most of the institutional buildings in the study area are schools. The largest of these are in the major centers and are therefore connected to community water supply systems. Some of the smaller or isolated schools are on well systems. The hospital at St. Anthony is on the community system of supply. Commercial buildings are usually quite small and few in number and motels are widely scattered along the coast with the main ones being at Rocky Harbour, Daniel's Harbour, Hawkes Bay, Plum Point and Pistolet Bay.

In reviewing the development of community water supply systems

in the Northern Peninsula, it has become apparent that, in attempts to assess groundwater potential, there has been a number of misconceptions, both on the part of the local people and the investigators. These ideas are not unique and show up from time to time in almost any part of the country. Nevertheless, specific reference has been made to some of these in the literature that is available pertaining to that area. The following examples are felt to be worthy of note:

a) In evaluating a particular well site close to a lake, it may be suggested that such a well should be a guaranteed producer with so obvious an abundance of water close by.

   The most important factor in this situation, however, is the permeability of the medium through which the drill hole is to penetrate. If the material is tight the well will in fact be a poor producer.

b) In some instances the assumption is made that, if surface water in an area is of poor chemical quality (re: drinking water standards) then groundwater will be likewise.

   The truth is that groundwater is often far superior in quality and may be totally unrelated to the factors contributing to the poor quality surface water.

c) Springs have been used in many instances in the Northern Peninsula for domestic water requirements and unfortunately their value has, on occasion, been overemphasized. It has been suggested that where a spring is located,a drilled well will probably encounter a high yield aquifer at depth.

The types of springs most often encountered are in reality,of low discharge and seldom produce more than 10 or 15 litres per minute. In addition, they are not that often related to the bedrock at greater depth in the same location.

FUTURE DEVELOPMENT - GROUNDWATER UTILIZATION

It is unfortunate that the most favorable groundwater areas are inland somewhat from the coastal areas, where the communities are situated. This is true for both the surficial deposits and the bedrock zones of known karst topography. The outwash deposits, even though many are inland, are relatively small and have low storage capactiy. They could not,therefore,be counted on to supply continuously large quantities of water from some of the larger communities or industrial consumers (fish plants).

The best potential for groundwater development would appear to be from bedrock aquifers in St. George Group carbonate rocks. Where fracturing and solution activity have created high permeability, it will be possible to develop high yield wells. Since these aquifers produce over 60 million litres per day in the Daniel's Harbour area, it is conceivable that such production can be obtained in other parts of the

peninsula underlain by the St. George Group. When considering this, though, it is important to understand fully the recharge characteristics of these aquifers because most fracture zones, fault zones, etc. are difficult to define and boundary conditions may exist short distances away. Consequently, it will be necessary to obtain considerable subsurface information from drill holes and pumping tests before being confident in the long-term safe yield. Very few of the government sponsored well drilling programs to date have been sufficiently funded in order for the required data to be obtained.

The Hawke Bay Formation has good potential for small community systems and institutions such as schools. Unlike the St. George Group, however, it does not appear capable of satisfying industrial demand such as in the processing of fish. The groundwater potential from the Hawke Bay Formation should be more fully evaluated in future since it may be possible to identify specific zones which can be selectively exploited. This could have the effect of raising the production statistics and elevating the status of the unit to a major aquifer.

CONCLUSIONS

The Northern Peninsula study area has, until comparatively recent times, suffered from lack of development. This is reflected in the scarcity of hydrogeological data. Although there have been periods of intense engineering activity (proposed Strait of Belle Isle Tunnel), much of the geotechnical data is irrelevant to the hydrogeology. Due to the overall lack of meaningful data it is not possible to develop a sound hydrogeological base from which to build, and therefore efforts

to compile useful hydrogeologic maps have been frustrated.

Until recently, there has been a noticeable lack of coordination in the aquisition, storage and retrieval of scientific data between government departments, both federal and provincial. The provincial Department of Mines and Energy has since made a concerted effort to retrieve data related to the earth sciences. Considerable information has been collected on the Northern Peninsula since Confederation which pertains to the following interrelated disciplines: i) Civil Engineering, ii) Geotechnical Engineering, iii) Mineral Explorations and Development, iv) Hydrogeology and Environmental Geology. In many instances much time is required to track down relevant data and much of this time is wasted in going from one government department to another before the desired material can be assembled. This has been evident in the Northern Peninsula study but probably to no greater a degree than it would in other parts of the island.

There have been no major aquifers identified in surficial deposits within the study area. At best, some of the existing granular deposits may be able to satisfy the requirements of some small unincorporated communities, or average size schools and motels.

Major bedrock aquifers exist within the carbonate rock sequence of the St. George Group - the Daniel's Harbour Mine area being typical. Similar geological environments may exist elsewhere on the peninsula and the potential for developing major underground water supplies in such areas may be quite good. Additional exploratory work will be required to delineate these productive zones but this should be willingly undertaken since the cost and effort may be amply rewarded.

Total annual groundwater withdrawal from all domestic and municipal drilled wells throughout the entire Northern Peninsula is insignificantly small. Consequently, there is no danger of overtaxing bedrock aquifers, except possibly in some isolated situation.

Many of the well drilling programs in the past have been improperly planned from the outset and have not had the benefit of hydrogeological expertise. Specifically, wells have been poorly located (sites often chosen by the driller), no observation wells have been included and no pump testing has been done. Accordingly, estimated yields have been in error and the follow up water supply systems have been inefficiently designed.

Groundwater chemical data throughout the study area is inadequate, and the data thus far collected is in most cases incomplete. Major cation and anion data are lacking and must be included in future programs if proper interpretation and coorelation of information is to be seriously attempted.

Chemical quality of groundwater is generally good from a health point of view but well water frequently contains excess of elements which make it aesthetically undesirable. Iron, manganese and colour are the most noticeable among these parameters and, depending on the concentrations, treatment may be necessary with some systems.

With the exception of the serious outbreak of dysentry in 1972, groundwater pollution has not been extensive on the Great Northern Peninsula. Nevertheless, it is probable that dug wells exist with unsafe water due to poor location, faulty construction and/or poor maintenance. Drilled wells offer greater protection and far fewer could be expected to be polluted than with dug wells.

Pollution due to highway salting has rarely occurred to date. Reported cases of salt contamination can be expected to increase substantially as greater quantities of salt are applied to the roads during the winter months and as vehicular traffic increases over the years.

Sea water intrusion of aquifers has not as yet taken place within the study area although there may be some isolated cases which have not been publicized. It is surprising that more cases have not been reported since a number of drilled wells are located adjacent to the coastline in areas of low terrain. One might expect reportings of salt water in a number of drilled wells in the near future.

RECOMMENDATIONS

The collection of data related to groundwater has picked up substantially in the past few years, due mainly to the policy and efforts of the Department of Consumer Affairs and Environment. In particular, well drillers are requested to keep logs of all wells drilled and note specific information such as static water level, yield, rock types, etc. It is vital that this information be recorded and eventually improved upon if and when an Act is passed obligating drillers to record pertinent data.

It is recommended that an intergovernmental committee (with some input from industry) be established to set up a system for the development of a data bank with a suitable storage and retrieval system, for all earth science related information. This would presumably carry the Department of Mines' system a step beyond the interest of the Mineral Industry, without adversely affecting the present efforts of that department.

It is recommended that certain areas underlain by St. George Group rocks be explored to identify zones having high groundwater potential. Such areas, if near the coast, may be capable of supplying fresh water for industrial purposes as well as for municipal requirements. In studying the St. George Group, attention should be given to previous studies carried out by mineral exploration companies, whose search for zinc mineralization has prompted a considerable amount of core drilling and geochemical mapping. This data should be reviewed for purposes of zeroing in on worhtwhile zones. Core drilling logs will be especially useful in such a study if sufficient detail has been recorded in core descriptions - eg. fracture frequency, vugs, and cavities, lost circulation of drilling fluid and penetration rates. The Department of Mines and Energy has on file the results of exploration activity carried out during the past thirty years or more and there has been extensive drilling and geochemical surveying completed during that period.

In considering the development of a major supply from a drilled well at least one,and preferably a minimum of two observation wells, should be included for each production well that is drilled.

Pump testing of drilled wells should be carried out whenever possible,other than for private domestic water supplies. These tests should be recommended for a period of 72 hours with careful procedures outlined for the monitoring of the aquifer behaviour. In instances where it is impractical to extend the test a full 72 hours, a minimum period of 24 hours may be acceptable, depending on the indicated well yield and the proposed demand. It is of the utmost importance to

pump for extensive periods in assessing fracture flow aquifers, which will be the most frequent type dealt with on the Northern Peninsula.

A water well monitoring system should be set up for both water level determinations and water quality assessment. This may include a number of existing drilled wells which could form part of a grid network for observation purposes.

It is recommended that more complete chemical testing be carried out on groundwater samples from wells other than individual domestic types. The groundwater section of Department of Consumer Affairs and Environment should have the opportunity to recommend the type of tests required for all government and industrial wells. Such recommendations would be based on the known hydrogeology of the area in question. Eventually, a regional map could be compiled designating zones in which certain chemical analyses must be performed, thus encouraging the buildup of more meaningful groundwater quality data.

A groundwater protection program related to both shallow and deep well construction should be initiated. This should include guidelines on site selection, considering highway salt pollution and sea water intrusion, in addition to the obvious concern over possible pollution from septic tanks and disposal fields.

CRITIQUE OF STUDY

This study has been the first regional hydrogeological study undertaken in the province of Newfoundland and Labrador. The area in question was chosen partly because of its geographic distinction,

history of development, and a concern over health hazards earlier associated with consumption of well water. It has also been considered as somewhat a pilot project to which any subsequent studies of a similar nature may be related.

It is questionable whether the area chosen for the first regional study has been the best choice. There are other regions where population concentrations are higher and considerably more wells have been drilled. Other geological information is also more plentiful. Most of the northeast coast from Green Bay to Conception Bay would fit into this category. On the other hand, having "broken the ground" in a region lacking in data, greater justice may be done on subsequent studies in regions with more available information. This should be especially true in the compilation of hydrogeological maps and in the interpretation of groundwater chemistry.

There was no fieldwork budgeted for this study. This was mainly due to the high cost of obtaining field information, especially subsurface data. This appeared to be a sound decision since it is a well known fact that it is almost impossible to get enough field information and a small amount is seldom of worthwhile benefit. In spite of this, it is felt that in future studies of this type, an allowance should be made for a minimal amount of fieldwork in order to fill data gaps. After all available office data has been collected and reviewed, any serious data gaps should be listed. A field trip of roughly three days duration could be made by a hydrogeologist. This would include such activities as examining well sites and having discussions with individual well owners, drillers, community officials and other interested parties

who are knowledgeable in relation to groundwater supply and local conditions.

Available well yield information has been almost exclusively based on drillers reports. It is impossible, therefore, to be very confident in designating the potential of a hydrostratigraphic unit. Based on their reports, any maps of groundwater availability could be grossly inaccurate in certain areas, and, this is especially true in dealing with fracture type permeability. The near absence of pump test data in the study area has been a particular disadvantage. Hence, it has been necessary to make certain assumptions, in terms of well yield and aquifer potential, which would otherwise have been more conclusive. This has tended to weaken the scientific approach to the study, in spite of efforts to the contrary.

The Great Northern Peninsula is inhabited along the coastal zone and the bulk of available data comes from this peripheral strip. This unidimensional distribution of information is obviously restrictive. One must realize, however, that most areas have developed in this manner throughout the province. Other hydrogeological studies will be subject to the same basic conditions and limitations. This has stemmed from the influence of the fishing industry, from the outset, on the development and distribution of population throughout the province.

In assessing the overall value of the study, consideration should be given to the written report and the maps separately. The report represents a worthwhile review and compilation of relevant data which has hitherto been widely dispersed. It has also brought to light the serious deficiencies which have existed in terms of developing the

groundwater resources of the Great Northern Peninsula. This in itself has been a fruitful exercise and will hopefully enable the Department of Consumer Affairs & Environment to control groundwater utilization in a practical manner. The maps on the other hand, do not represent as complete a hydrogeological expression as was hoped. The bedrock geological map, although useful, is essentially a composite of three or four existing maps available from the Department of Mines and Energy. The surficial geology is a composition from the work of D. R. Grant. Both of these maps are valuable but contain little in the way of additional useful information gained from the study. The map entitled "Hydrogeology" contains a modest amount of hydrogeological information but suffers from the obvious lack of data which was available.

In summary, it may be stated that the study has been a worthwhile exercise and the report should be of benefit to a multitude of people in a variety of disiplines. The majority of these, however, will probably find it beneficial in a general way only. Additional studies of this type should only be considered in selected areas where development is significant.

REFERENCES

GRANT, D.R.

1969a: Surficial Deposits, Geomorphic Features, and Late Quaternary History of the Terminus of the Northern Peninsula of Newfoundland and Adjacent Quebec-Labrador; Mar. Sed., v.5, p. 123-125.

1969b: Late Pleistocene Re-advance of Piedmont Glaciers in Western Newfoundland; Mar. Sed., v.5, p. 126-128.

1972: Postglacial Emergence of Northern Newfoundland; Geol. Surv. Canada, Paper 72-1, part B, p. 100-102.

1973: Terrain Conditions, Gros Morne National Park, Western Newfoundland; Geol. Surv. Canada, Paper 73-1, part B, p. 121-125.

1974: Prospecting in Newfoundland and the Theory of Multiple Shrinking Ice Caps; Geol. Surv. Canada, paper 74-1B, p. 215-216.

1977: Altitudinal Weathering Zones and Glacial Limits in Western Newfoundland, with Particular Reference to Gros Morne National Park; Geol. Surv. Canada, Paper 77-1A, p. 455-463.

MACCLINTOCK, P., and TWENHOFEL, W.H.

1940: Wisconsin Glaciation of Newfoundland; Bull. Geol. Soc. America, v. 51, p. 1729-1756.

TWENHOFEL, W.H. and MACCLINTOCK, P.

1940: Surface of Newfoundland; Bull. Geol. Soc. America, v.51, p. 1665-1728.

WILLIAMS, H., KENNEDY, M.J., and NEALE, E.R.W.

1972: The Appalachian Structural Province; in Variations in Tectonic Styles in Canada (R.A. Price and R.J.W. Douglas, eds), Geol. Assoc. Canada, Spec. Paper 11, p. 182-261.

1974: The Northeastward Termination of the Appalachian Orogen; in The Ocean Basins and Margins, vol. 2, (A.E.M. Nairn and F.G. Stehli, eds.), Plenum, New York, p. 79-123.

BIBLIOGRAPHY

Besaw, D.M., 1975 - Report on Geologic Mapping, Strait of Belle Isle Region for Strait of Belle Isle Crossing, Teshmont Consultants Ltd., Report ER-133-70100-2, 20 p.

_____, 1975 - Report on Site Investigation at Yankee Point, Newfoundland Shaft Site, Strait of Belle Isle Crossing, Gull Island Power Company Limited, Appendix, 12 p.

Davenport, P.J., Hornbrook, E.H.W., and Butler, A.J.,1974 - Geochemical Lake Sediment Survey for Zn and Pb Mineralization over Cambro-Ordovician Carbonate Rocks of Western Newfoundland, Dept. of Mines & Energy, Province of Newfoundland, 8 p.

Gorman-Butler Assoc. Ltd. - Preliminary Report, Water System for Community of Daniel's Harbour, Gorman-Butler Associates Ltd., Project E-3966, p. 1-5.

Gorman-Butler Assoc. Ltd. - Preliminary Report on Proposed Water and Sewerage Utilities, St. Paul's-St. Barbe South, Gorman-Butler Associates Ltd., Project E-3870, P. 1-4.

Gorman Associates & Company Ltd., Bellburns - Preliminary Report for a Water System, Gorman Associates & Company Ltd., Project No. E-47-65, 5 p.

Jamieson, A., 1974 - A Water Quality Atlas for Streams and Lakes of Insular Newfoundland, Fisheries and Marine Service, Newfoundland Region, 22 p.

Knight, Ian, 1977 - Cambro-Ordovician Platformal Rocks of the Northern Peninsula, Newfoundland, Dept. of Mines & Energy, Gov't of Newfoundland & Labrador, Report 77-6, 27 p.

Newfoundland Design Assoc. Ltd., 1965 - Brief Report on a Water System for St. Anthony Bight, Newfoundland Design Assoc. Ltd., 2 p.

Newfoundland Design Assoc. Ltd., 1979 - Water Supply System and Subdivision Sewer Outfall, Hawke's Bay, Nfld, Newfoundland Design Assoc. Ltd., 8 p.

Newfoundland Design Assoc. Ltd., 1971 - Feasibility Study Water System, St. Lunaire-Griquet, Newfoundland Design Assoc. Ltd., 5 p.

Nolan, White & Assoc. Ltd., 1969 - Groundwater Feasibility study, Englee for Deleuw Cather Co. of Canada, Engr. Report.

Nolan, White & Assoc. Ltd., 1972 - Water Supply Study, Communities of Anchor Point, Pond Cove, Shoal Cove and Reefs Harbour for Dept. Community and Social Development, Engr. Report.

Nolan, White & Assoc. Ltd., 1973 - Groundwater Assessment, Main Brook for Dept. Municipal Affairs & Housing, Engr. Report.

Nolan, White & Assoc. Ltd., 1975 - Water Supply Feasibility Study, Flowers Cove Area for Teshmont Consultants Limited, Engr. Report.

Nolan, White & Assoc. Ltd., 1975 - Materials Survey, Strait of Belle Isle Area, for Teshmont Consultants Limited, Engr. Report.

Nolan, White & Assoc. Ltd., 1975 - Groundwater Study, Shallow Bay for Parks Canada, Engr. Report.

Nolan, White & Assoc. Ltd., 1975 - Groundwater Study, Barry Hill Campground for Parks Canada, Engr. Report.

Nolan, White & Assoc. Ltd., 1975 - Quarry Investigation, Gros Morne National Park, for Federal Department Public Works.

O'Keefe, Ronald T., 1975 - Preliminary Engineering Report Water and Sewerage Systems, St. Paul's-St. Barbe South, Newfoundland, R.T. O'Keefe, Consulting Engineer, p. 1-5.

Patrick Harrison & Co. Ltd., 1975 - Report on Strait of Belle Isle Tunnel Shaft, Patrick Harrison & Company Ltd., 17 p.

Robinove, Charles J. - Remote-Sensor Applications in Hydrology, U.S. Geological Survey, p. 25-32.

Stancioff, Andrew and Hill, Patrick A., 1977 - Satellite Image Analysis in Mineral Exploration in Complicated Structural Terraines: Great Northern Peninsula, Newfoundland, A.A.P.G. Symposium on Remote Sensing-Pecora, Ill., 22 p.

Terpstra Municipal Engineering Assoc. Ltd., 1978 - Raleigh Water and Sewer Facilities Feasibility Study, Terpstra Municipal Engineering Assoc. Ltd., 6 p.

APPENDIX "A"

Climatic Data Distribution Maps

Temperature

Precipitation

Evaporation

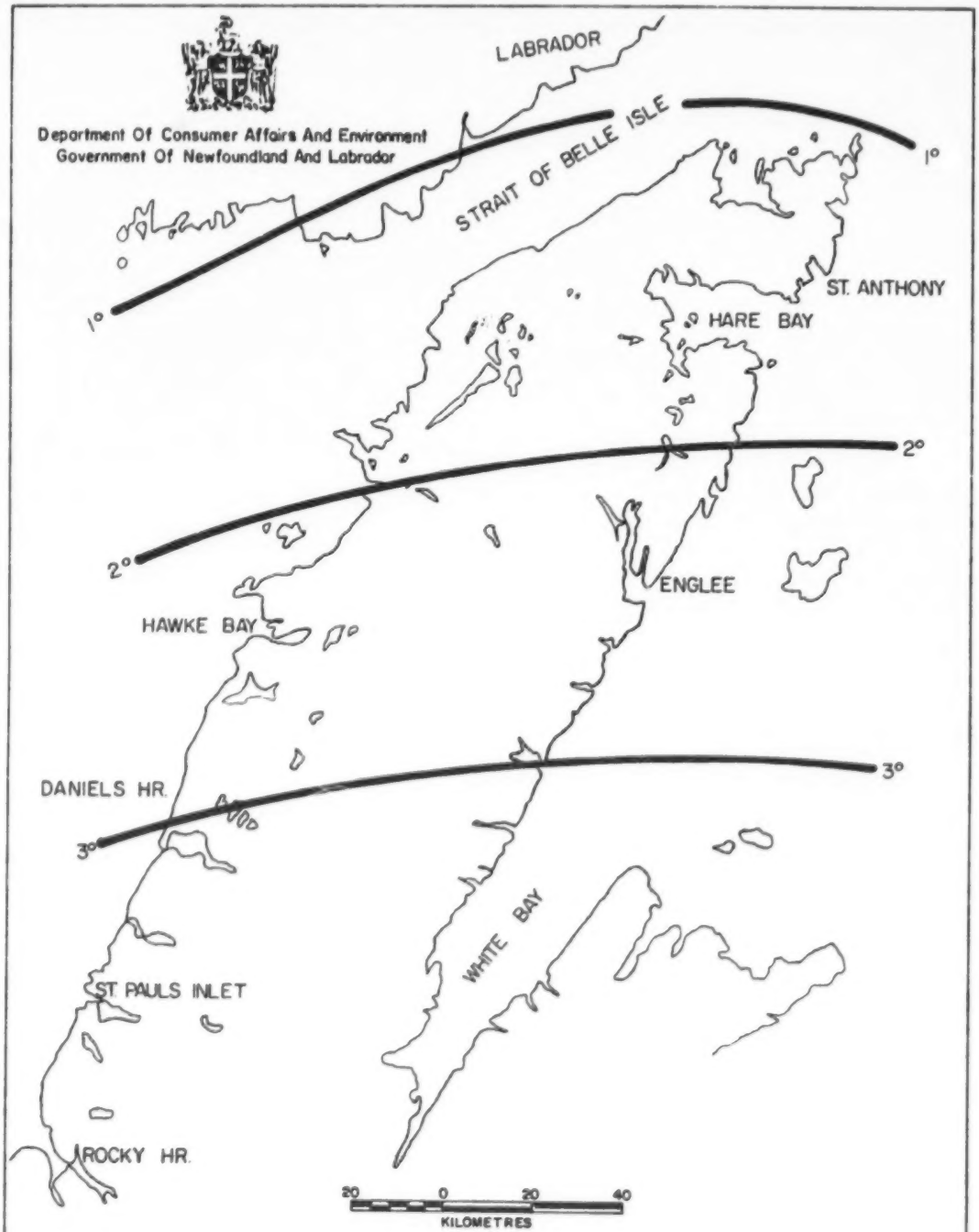


FIGURE NO: 5 Mean Annual Temperature Distribution (mm), Great Northern Peninsula, Newfoundland

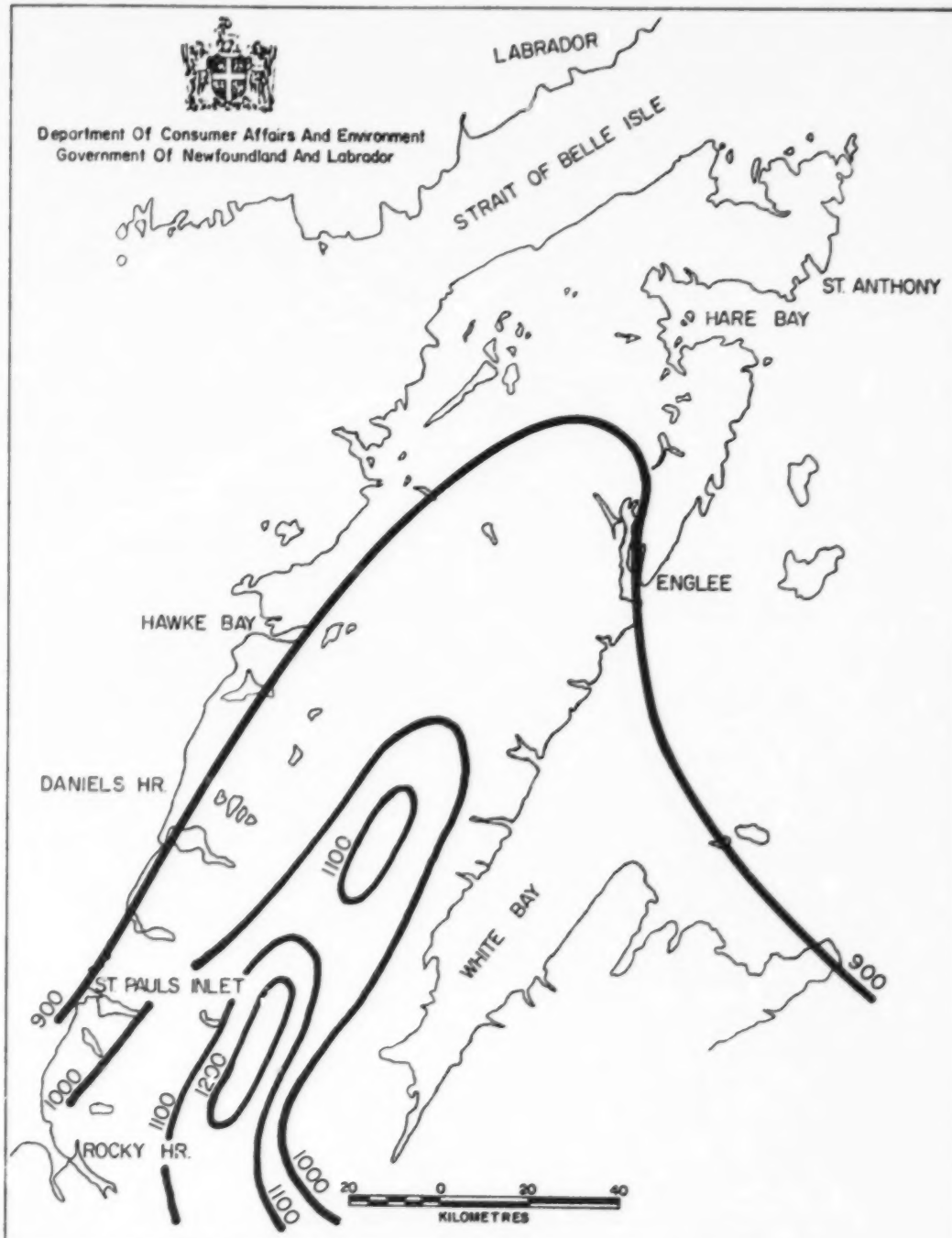


FIGURE NO: 6 Annual Precipitation Distribution (mm), Great Northern Peninsula, Newfoundland

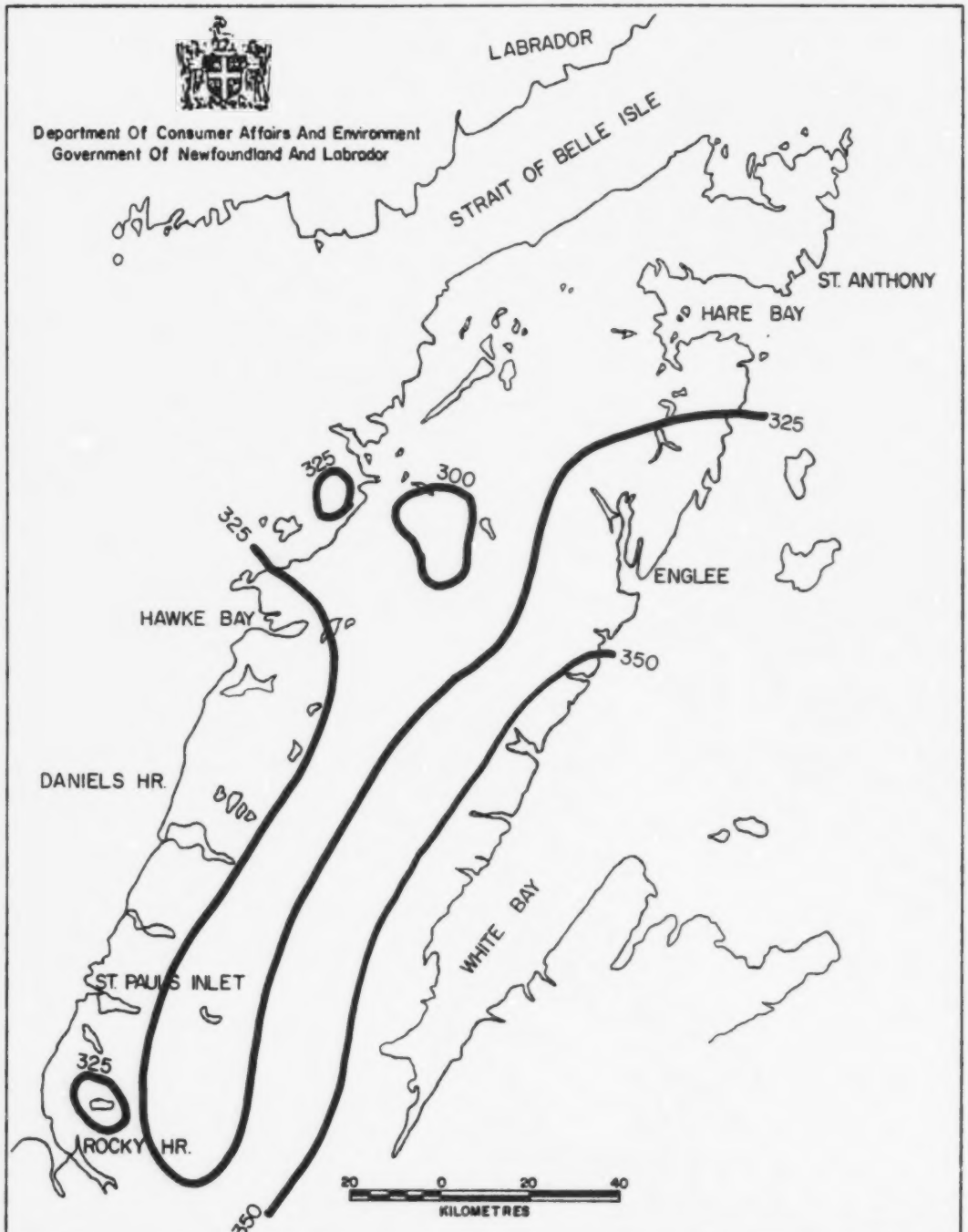


FIGURE NO: 7 Annual Evaporation Distribution, (mm) Great Northern Peninsula Newfoundland

APPENDIX "B"

Precipitation and River Basin Discharge Data - Specific Areas

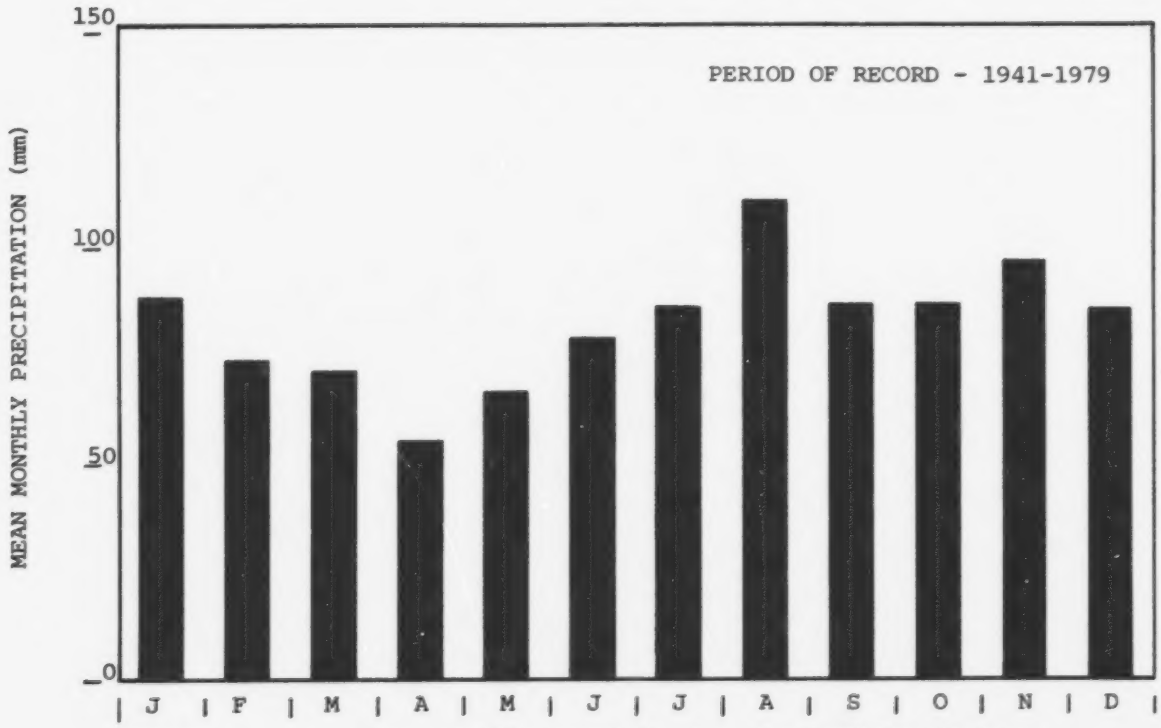


FIGURE 8 Mean monthly precipitation for Daniel's Harbour

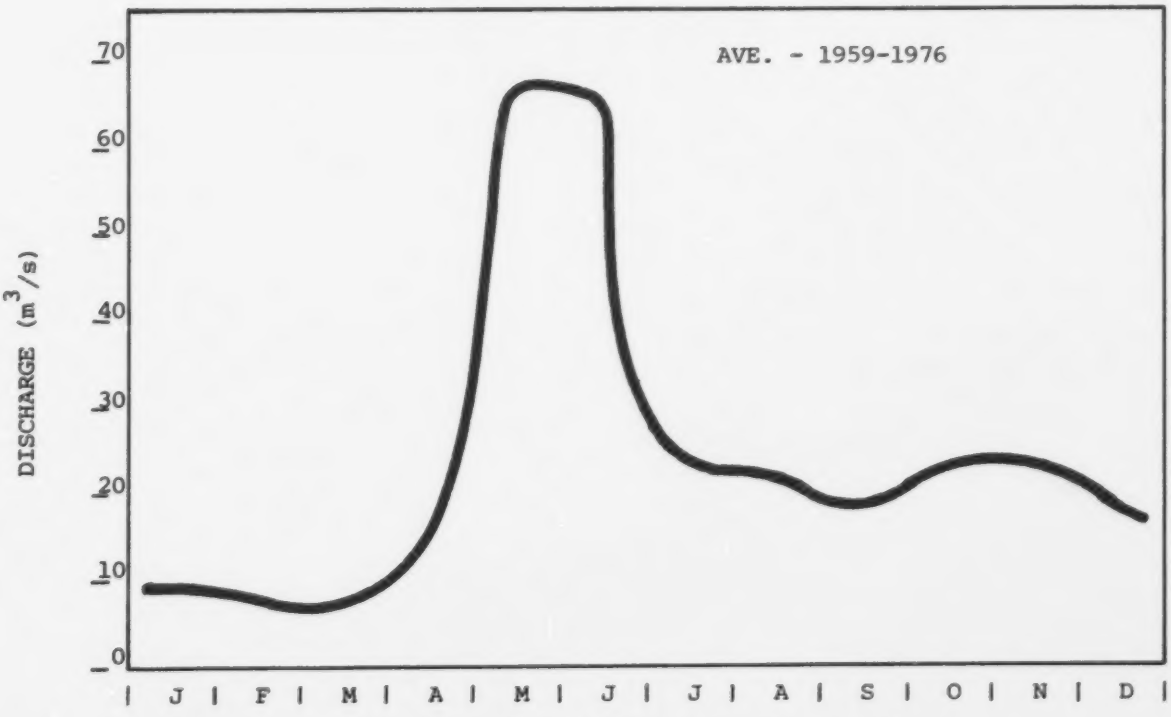


FIGURE 9 Mean monthly discharge for Torrent River

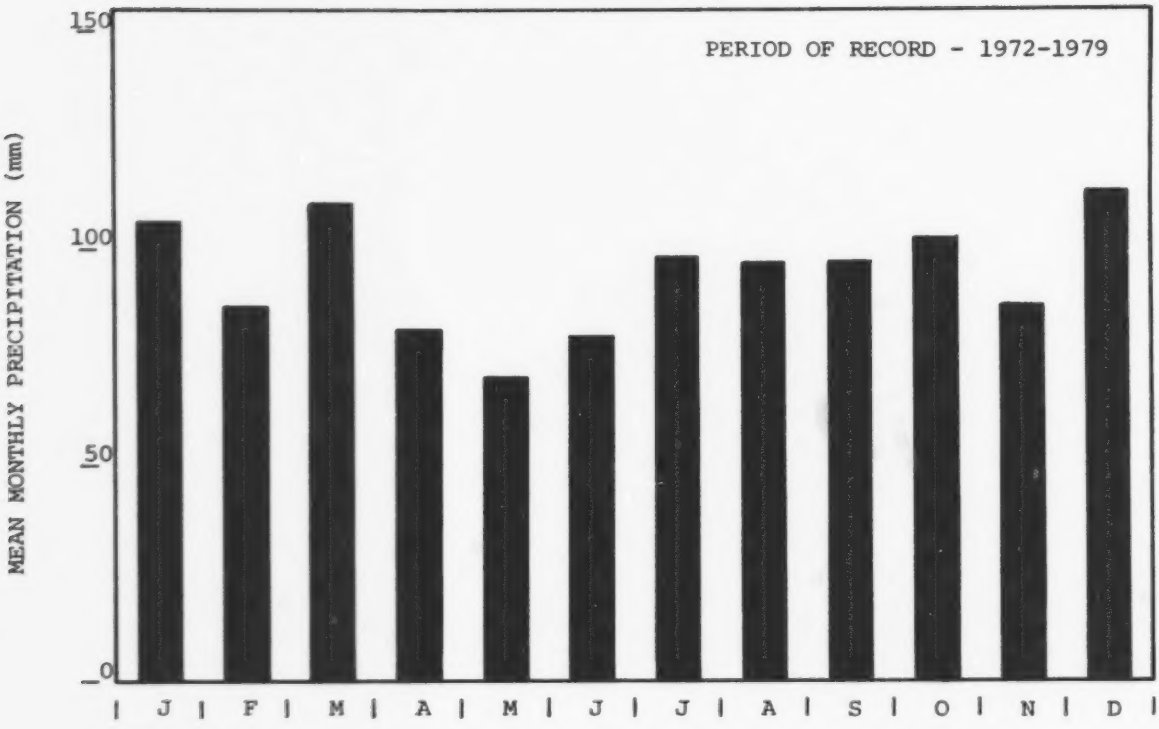


FIGURE 10 Mean monthly precipitation for Plum Point

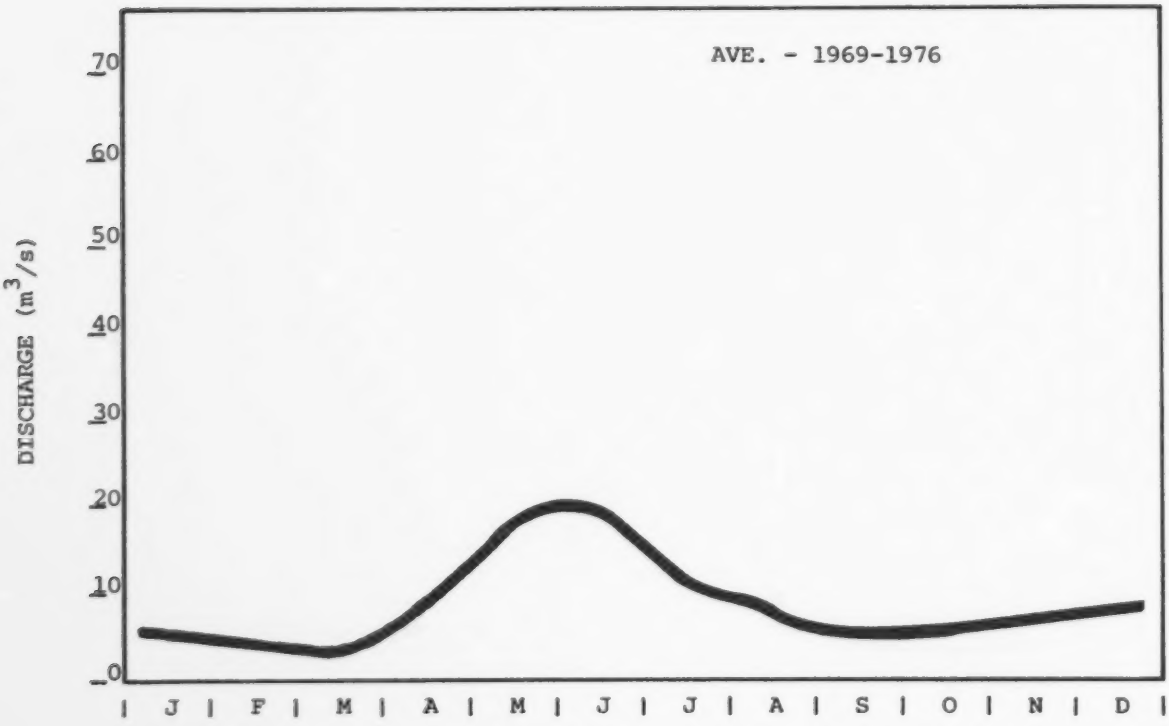


FIGURE 11 Mean monthly discharge for St. Genevieve River

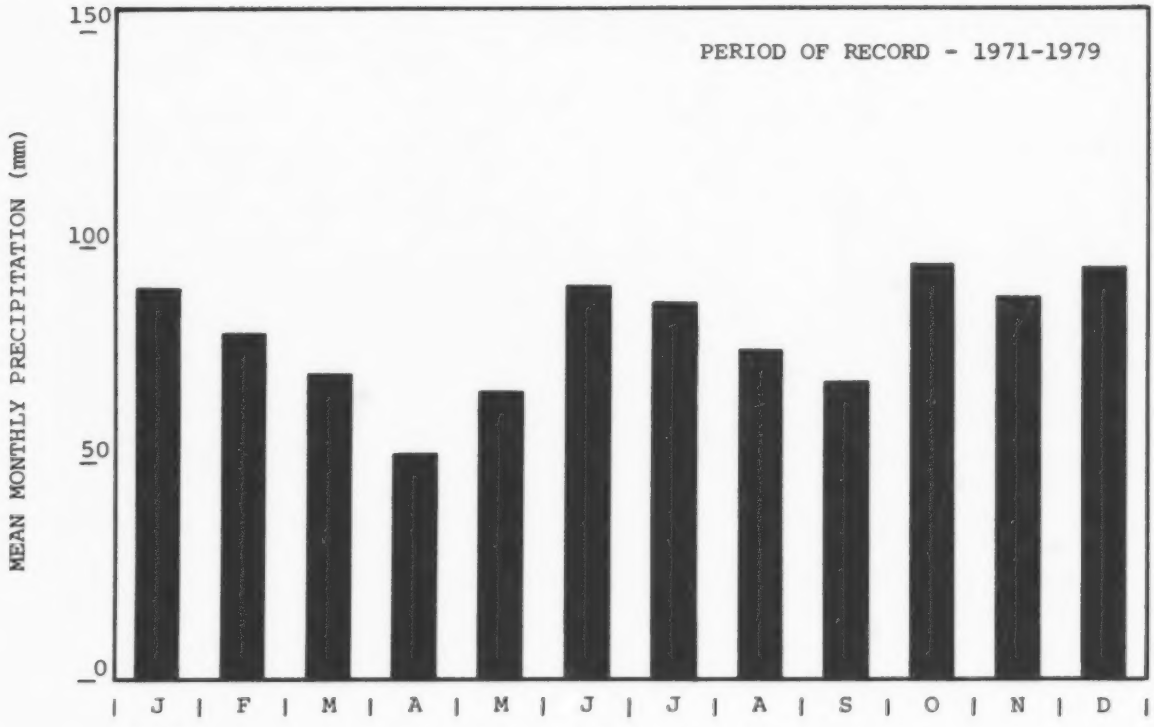


FIGURE 12 Mean monthly precipitation for Roddickton

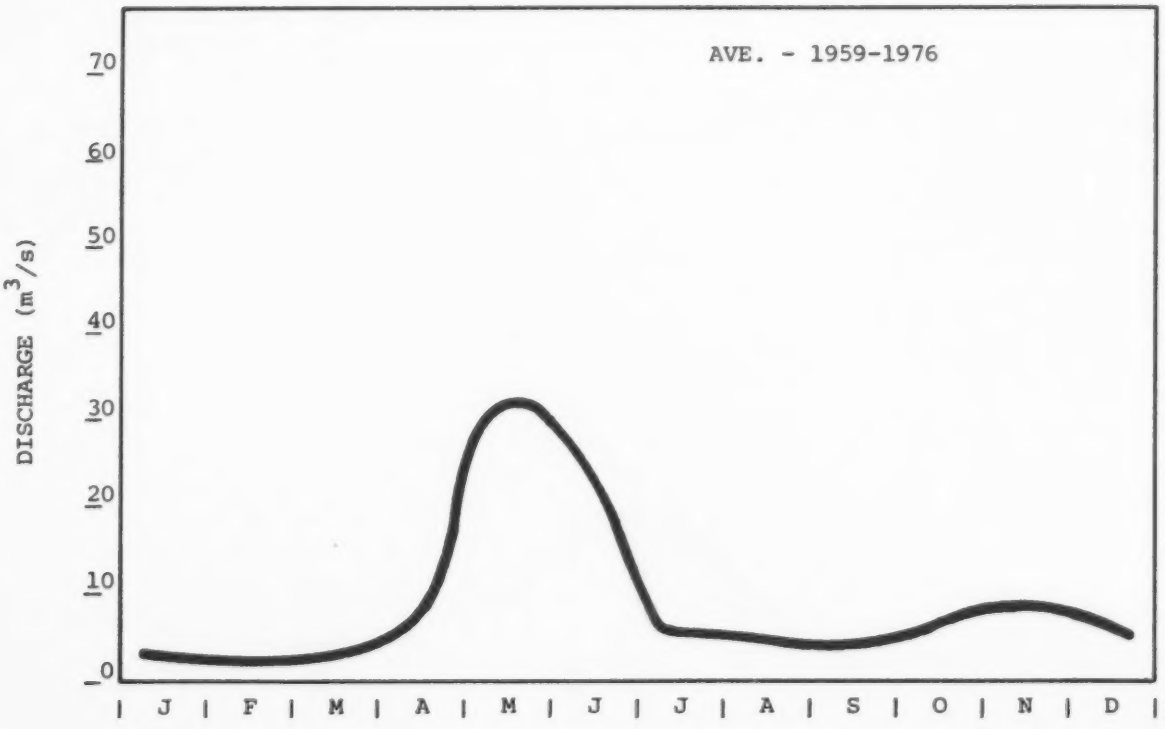


FIGURE 13 Mean monthly discharge for Beaver Brook

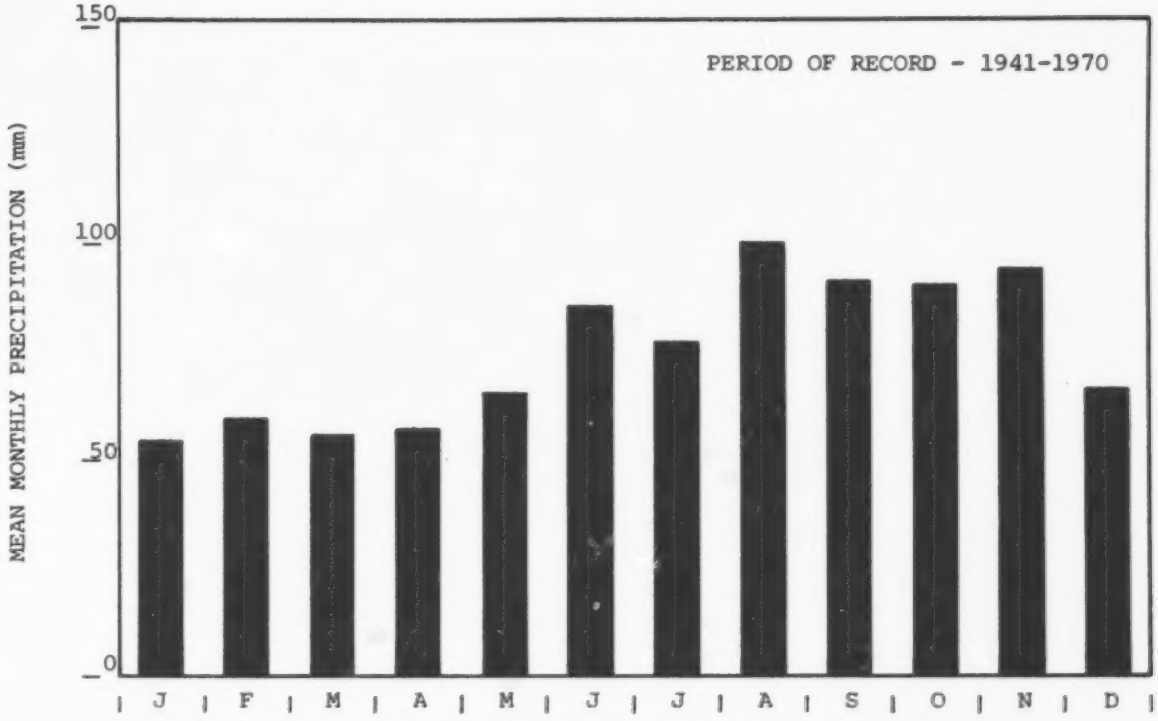


FIGURE 14 Mean monthly precipitation for Belle Isle

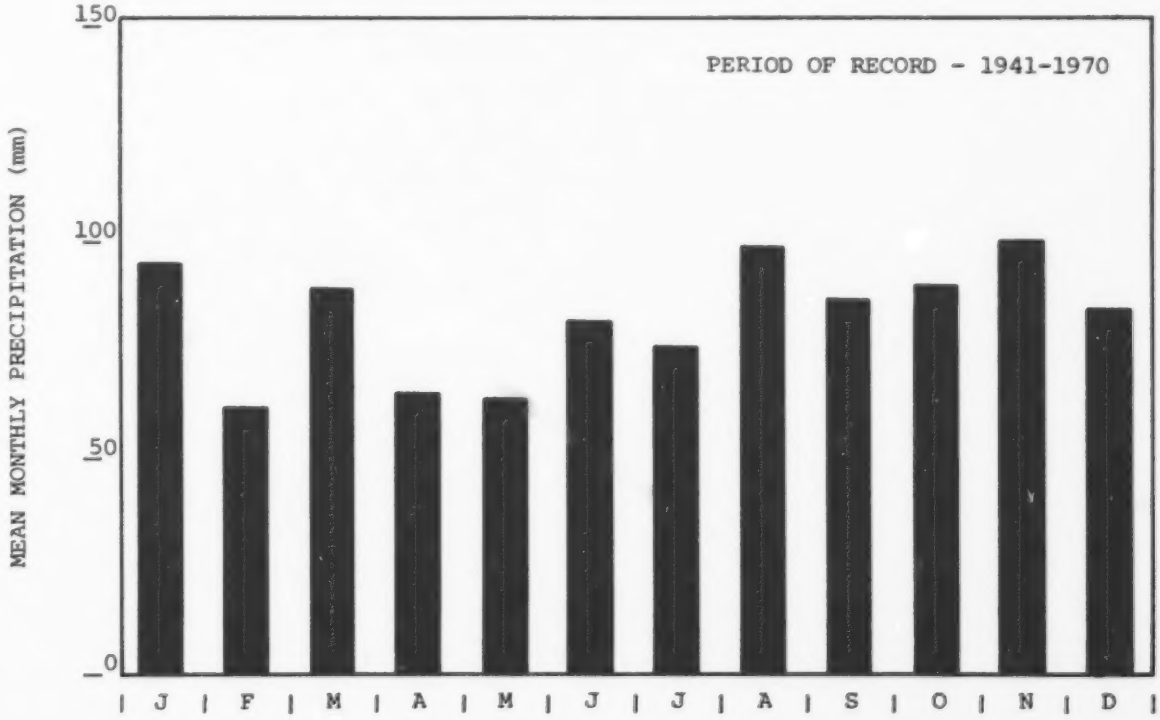


FIGURE 15 Mean monthly precipitation for St. Anthony

DEPARTMENT OF CONSUMER AFFAIRS AND ENVIRONMENT
GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

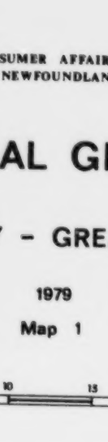
SURFICIAL GEOLOGY

HYDROGEOLOGICAL STUDY - GREAT NORTHERN PENINSULA

1979

Map 1

Kilometres 5 0 5 10 15 20 25 30



INSULA

STRAIT OF BELLE ISLE

Cape Norman

Wild Bight

Cook's Harbour

Pistolet Bay

Milan

Eddies Cove

Green Island Brook

Green Island Cove

Payne's Cove

Shoal Cove

Sandy Cove

Savage Cove

Nameless Cove

Flowers Cove

Captain Pond Cove

Bear Cove

Goose Arm

Genge Pt

Anchor Point

St Barbe

Black Duck Cove

Eastern Pt

Current I

Goose Island

Ste Genevieve Bay

Pond Cove

Seal Point

Blow Me Down

Old Ferolle Island

Plum Point

Forked Pond

Big Bay

Bird Rock

Ferolle Pt

Hare Point

St Margarets Bay

South Harbour

Goldstone Point

Middlemore Bay

Ten Mile Lake

Round Lake

Eagle Pond

Salmon Pond

Northern Arm

Hare Island

Lock's Cove

Hudson Bay

Hudson Pt

Fournier Pt

Jack Paley's Island

Brent Islands

Fox Harbour

Fox Harbour Pt

Grenfell

Nameless Cove

Cape Onion

Quirpon

Quirpon Island

Quirpon Pt

Cape Bauld

Bauld Pt

Bauld Island

Bauld Cove

Bauld Harbour

Bauld Pond

Bauld Hill

Bauld Lake

Bauld Brook

Bauld Pt

N

GULF OF ST LAWRENCE

St John

Bay

St John Island

Barr'd Harbour

ST BARBE NORTH DISTRICT

ST BARBE SOUTH DISTRICT

HIGH LANDS OF ST JOHN

Ingornachoix Bay

Hawkes Bay

Port Saunders

Bartletts Harbour

St Margaret Bay

Ten Mile Lake

Round Lake

Canada Bay

Canada Harbour

Englee

Williamsport

Grey Harbour Depot

Pointe Riche Peninsula

Spirity Cove

River of Ponds

Maidigwin Bay

Black Duck Brook

Current I.

Seal Point

Pond Cove

Old Ferolle Island

Plum Point

Big Bay

Bird Cove

New Ferolle

Ferolle Pt.

Shoal Cove

Oaktree Point

Castor Point

Flat Island

Turr Islands

Photograph Point

Seal Rocks

Square Rock

Round Head

Fish Point

Hunters Point

Old Man Cove West

Barbace Point

Keppel I.

Burntwood Point

Pond Island

Big Island

Mt. Misery

Mt. Michaels

Mt. Hope

Mt. Ellis

Mt. Ellis Brook

Mt. Ellis Pond

Mt. Ellis Cove

Mt. Ellis Point

Mt. Ellis Island

Mt. Ellis Harbour

Mt. Ellis Bay

St John
Bay
St John Island
Barr'd Harbour
Hawkes Bay
St Margarets Bay
Barrletts Harbour
Mount Misery
Mount St Margaret
Round Lake
Ten Mile Lake
Salmon
Big Bay
Bird Cove
Plum Pond
Seal Point
Current I
Black Duck Cove
Bay
Eagle Pond
Old Ferolle Island
Ferolle Pt
Oderin Point
Maldigate Bay
Beads Harbour
Castors River
Castor Point
James Island
Turn Islands
Town Islands
Fish Point
Hawkes Cove West
HIGH LANDS OF ST JOHN
SOUTH SUMMIT
NORTH SUMMIT
ST BARBE NORTH DISTRICT
ST BARBE SOUTH DISTRICT
Fleur de Lis
Brook
Brook
Brook

GULF OF

WHITE BAY

LEGEND

1 BEDROCK

2 MORAINE –

3 MARINE DE

4 GLACIOFLUV

SOURCE OF

Hawkes Bay
Great Harbour Deep
Little Harbour Deep
Jackson's Arm
Open Head
Sops Island
WHITE BAY
WHITE BAY
Williamsport
Fourchel Harbour
Grande Point
Eastern Head
Western Head
Big Head
Cobbler Hd
Coney Head
Frenchmen's Hd
Virgin Pt
Big Cove
Eastern Head
Western Head
Big Head
Cobbler Hd
Coney Head
Frenchmen's Hd
Virgin Pt
Open Head
Sops Island
ST BARBE SOUTH DISTRICT
WHITE BAY SOUTH DISTRICT
ST BARBE SOUTH DISTRICT
WHITE BAY SOUTH DISTRICT
N O R T H E R N
A R M
R I V E R
Great Cat Arm
Great Cat Arm
Little Cat Arm
Little Harbour Deep Head
Little Harbour Deep
Little Harbour Deep
Great Harbour Deep
Great Harbour Deep
Great Harbour Deep Head
Great Cat Arm
Little Cat Arm
Little Harbour Deep Head
Little Harbour Deep
Little

WHITE BAY

GROS MORNE

NATIONAL PARK

LEGEND

1 BEDROCK

2 MORAINE

3 MARINE DE

4 GLACIOFLU

SOURCE OF

D. R. Gra

LEGEND

1 BEDROCK - exposed or near surface, undifferentiated.

2 MORAINE - includes ground moraine and end moraine: till, silt to gravel sizes, minor clay.

3 MARINE DEPOSITS - includes beach berms, strand lines and wave cut beaches: fine sand to gravel, occasional silt.

4 GLACIOFLUVIAL - alluvial fans and terrace deposits: fine sand to gravel, generally clean with only traces of silt.

SOURCE OF INFORMATION:

D. R. Grant - Surficial Geology 1:50,000 map sheets
Great Northern Peninsula

NOLAN, WHITE & ASSOCIATES LTD.

DEPARTMENT OF CONSUMER AFFAIRS AND ENVIRONMENT
GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

BEDROCK GEOLOGY

HYDROGEOLOGICAL STUDY - GREAT NORTHERN PENINSULA

1979

Map 2

Kilometres 5 0 5 10 15 20 25 30

PENINSULA

STRAIT OF BELLE ISLE

HARE BAY

Cape Norman

Wild Bight

Cooks Harbour

Pistolet Bay

Green Island Cove

Northern Arm

Fourmile Pt

Brant Islands

Jacks Patey's Pt

Main Brook

Round Lake

Two Mile Lake

St Margarets Bay

Middle Arm

Quirpon

Ireland's Eye

Eddies Cove

St Carols (French Pt)

St Anthony

St Anthony Bight

Goose Arm

Deep Bay

Seal Point

Old Fernie

Big Bay

Flowers Island

Green Island

Cape Onion

Burnt Cape

Cape Bauld

Quirpon Island

Fox Island

Fox Island River

Eddies Cove West

Eddies Cove East

Goose Cove

Goose Cove East

Goose Cove Pt

Goose Cove Island

Goose Cove Island Pt

Goose Cove Island Pt

Goose Cove Island Pt

GULF OF ST LAWRENCE

St John Bay

Barr'd Harbour

St John Island

Bartletts Harbour

St Margarets Bay

Hawkes Bay

Ingornachoix Bay

Port Saunders

Round Lake

Trout River Lake

ST BARBE NORTH DISTRICT

ST BARBE SOUTH DISTRICT

HIGH LANDS OF ST JOHN

SOUTH SUMMIT

Cape Rouge Peninsula

Northeast Crouse

Conche Peninsula

Conche

Goddickton

Englee

Canada Bay

Canada Harbour

Williamsport

Bartletts Harbour

St John Island

Barr'd Harbour

Hawkes Bay

St John

Bay

Round Lake

Eagle Pond

Two Mile Lake

Seal Point

Old Ferolle Island

Plum Point

Big Bay

Blue Gull Pond

Ferolle Pt

New Ferolle

Shoal Cove

St Margarets Bay

Oxbow Point

Maidagoose Bay

Black Island

Sandbeach Cove

Castors Point

Castors River

Main Brook

Second Salmon

Salmon

Fire Lookout

Hemp Pond

Grandy's

St Julien's

Beach I

Flowerpot Cove

Northeast Crouse

Harbour

Windy Pt

Yellow Cove

Clam Cove

Pyramid Point

Cape Rouge

Cape Rouge Harbour

Cape Fin

Big Wild Cove

White Horse Head

Chimney Cove

Bide Arm

Brown Bush Point

Wild Cove

Canada Head

Canada Harbour

Flagstaff Point

Canada Cove

Wiseman Harbour

Gambell Point

Little Hawke Bay

Fresh Pond

Fresh Water

Fresh Harbour

Green Point

Fox Point

Old Fort

Fox Cove

Old Fort Cove

Fox Cove Head

Fox Cove Point

Fox Cove River

Fox Cove Mountain

Fox Cove Mountain Pond

Fox Cove Mountain Ponds

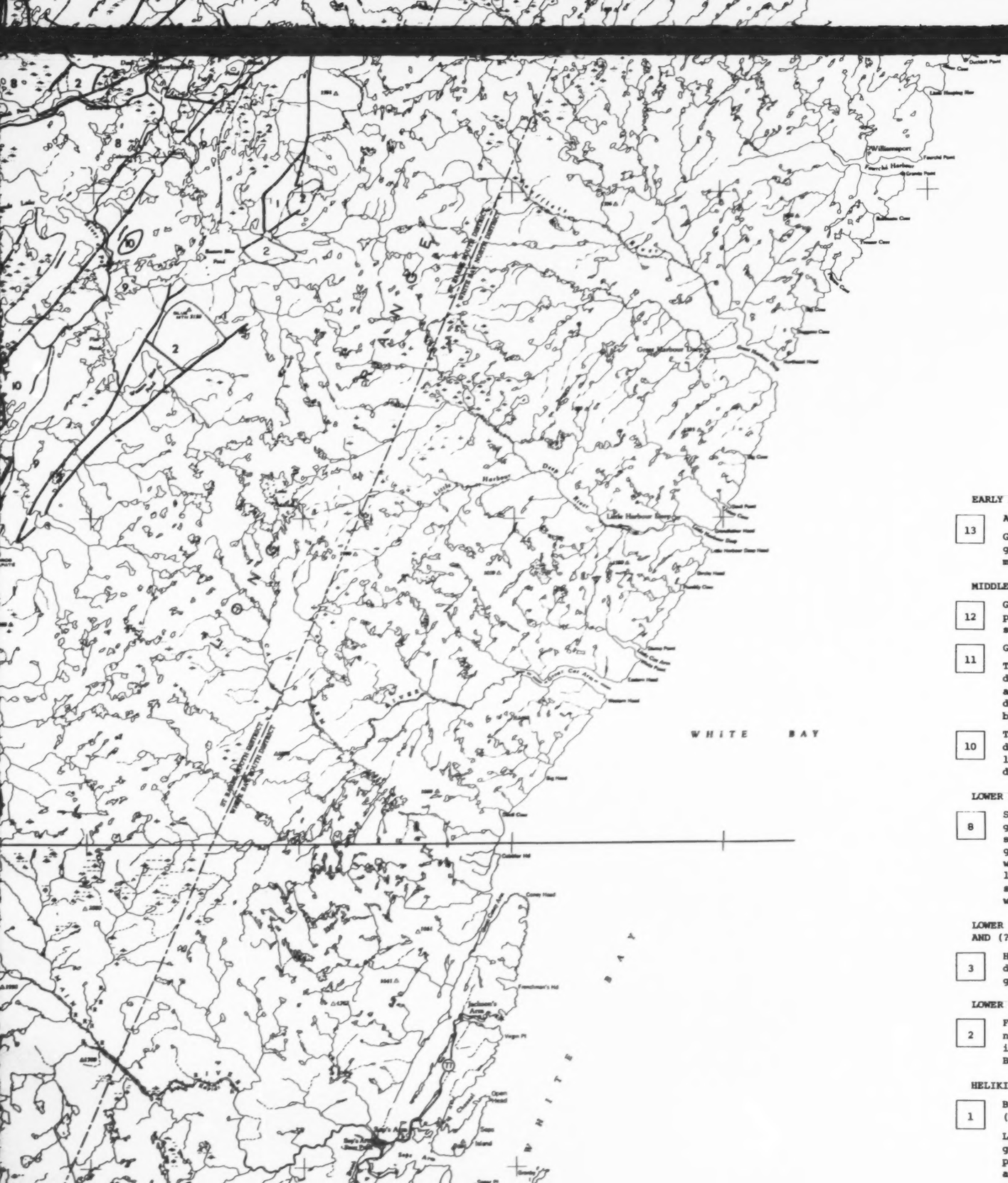
Fox Cove Mountain Pond

Fox Cove Mountain Ponds

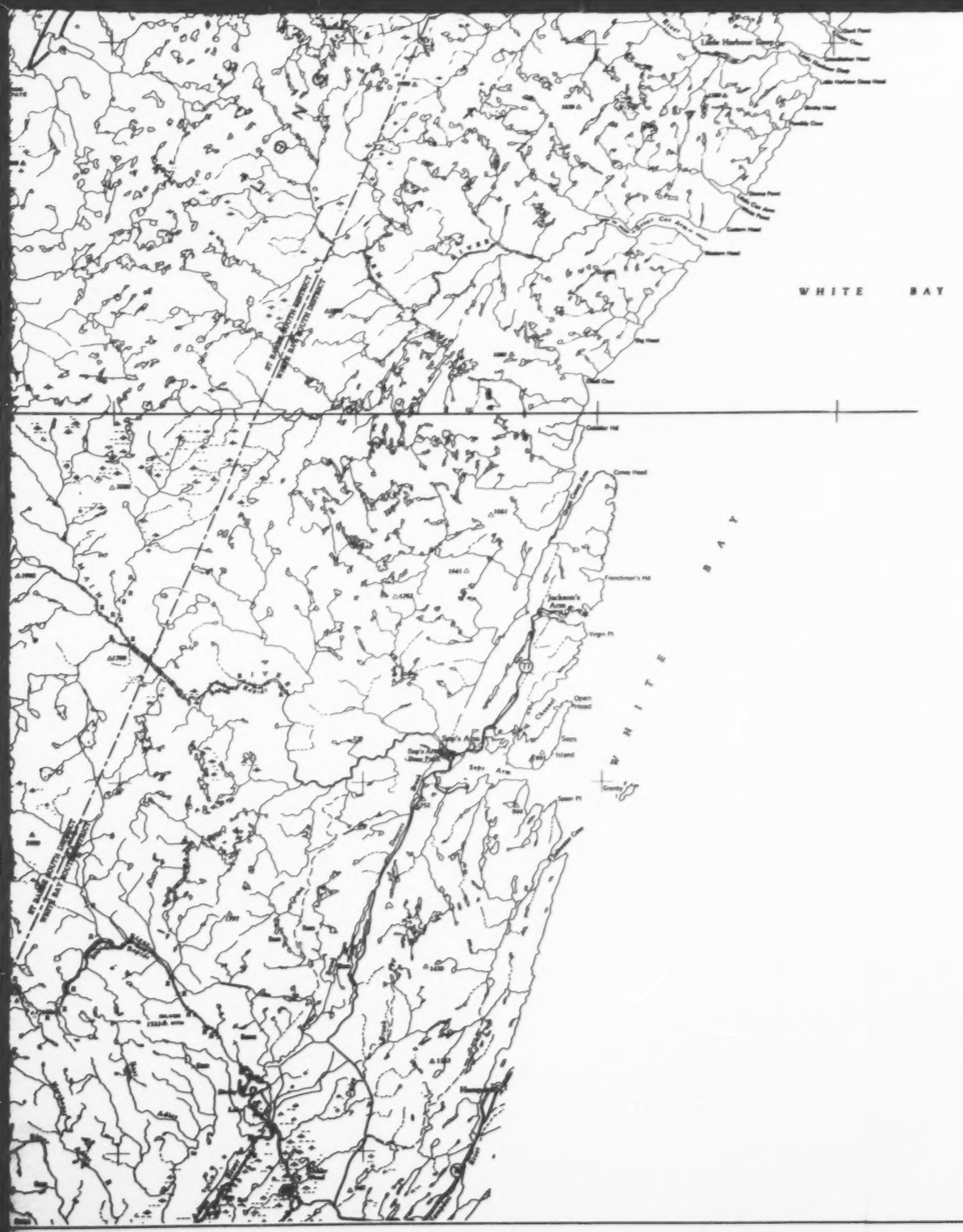
Fox Cove Mountain Pond

Fox Cove Mountain Ponds

GULF OF
WHITE BAY
WHITE BAY
River of Ponds
Daniel's Harbour
Portland Creek
Pond
Western Brook Pond
Pools Inlet
Little Harbour Deep
Harbour Deep
Deep River
Jackson's Arm
Sop's Arm
Open Island
Cobbler Hd
Corner Head
Franchman's Hd
Virgin Pt
Big Head
Bald Cliff
Table Point
Table Cove
Bellburns
Eastern Head
Portland Cove
Cliffs Point
Brown Pt
Gulls Island
Martin Pt
Sally's Cove
Big Cove
Little Harbour Deep
Little Harbour Deep Head
Eastern Head
Big Cove
Little Harbour Deep
Little Harbour Deep Head
Eastern Head
Big Cove
Big Cove
Big Cove


WHITE BAY
Deadman Point
Dunbar Point
Lower Hooping Harbour
Williamsport
Fairchild Point
Fairchild Harbour
Grassy Point
Ballistic Cove
Tarrant Cove
Big Cove
Cooper Harbour Point
Deep Harbour
Little Harbour Deep
Little Harbour Deep Head
Little Harbour Deep Point
Stone Head
Stone Cove
Eastern Head
Western Head
Big Head
Grand Cove
Cobbler Hill
Cobbler Head
Cobbler Cove
Cobbler Point
Cobbler Island
Cobbler Rock
Cobbler Reef
Cobbler Shoal
Cobbler Ledge
Cobbler Ledge Point
Cobbler Ledge Cove
Cobbler Ledge Head
Cobbler Ledge Island
Cobbler Ledge Rock
Cobbler Ledge Reef
Cobbler Ledge Shoal

WHITE BAY
GROS MORNE
NATIONAL PARK
Daniel's Harbour
Portland Creek Pond
Western Brook Pond
Bonne Bay
Trout River
Woody Point
Rocky Harbour
Norris Point
Broom Pt
Gulle Marsh
Martin Pt
Sally's Cove
Lobster Cove
Berry Hill
Shallow Bay
Deadman's Bay
Parsons Pond
Green Point
Cow Head
Jackson's Arm
Sop's Arm
Sops Island
Open Head
Frenchman's Hd
Virgin Pt
Sheer Pt
Big Head
Cobbler Hd
Corney Head
Western Head
Eastern Head
Little Harbour Deep Head
Little Harbour Deep Point
Shoe Cove Point
Lower Cove Arm
Middle Cove Arm
Upper Cove Arm
Shoe Cove Arm
Portland Creek
Eastern Head
Portland Creek Pond
Western Brook Pond
Bonne Bay
Trout River Pond



EARLY CARBONIFEROUS

13 ANGUILLE GROUP

Grey, dark grey and greyish green sandstones and micaceous sandstones, grey conglomerates, arkosic conglomerates, and arkosic sandstones; minor dark shale and argillite; all are dense, well indurated.

MIDDLE ORDOVICIAN

12 GOOSE TICKLE FORMATION: grey siltstone, shale, slate, and greywacke, minor pebble to cobble conglomerates, also includes marble and limestone beds, semi-pelitic, pelitic, and calc-silicate schist and minor marble.

11 GREEN POINT-ST. PAULS GROUP

Thin-bedded limestone, abundant limestone breccia, shale and siltstone; commonly abundantly fossiliferous in shaly beds

10 TABLE HEAD FORMATION: light to dark grey, hackly-weathering limestone passing upwards into dark grey shale

LOWER ORDOVICIAN

8 ST. GEORGE GROUP: light to dark grey and buff dolomite and limestone; dolomite containing greater than thirty percent white sparry dolomite; stylolitic limestone; porous coarsely crystalline dolomite; and dolomite with grey to brown chert nodules

LOWER & MIDDLE CAMBRIAN
AND (?) UPPER CAMBRIAN

3 HAWKE BAY FORMATION: light to dark grey dolomite, interbedded grey shale; white orthoquartzite

LOWER CAMBRIAN

2 FORTEAU FORMATION: red to grey nodular limestone and grey shale; includes basal unit at Canada Bay of purple and white limestone

HELIKIAN AND/OR APHEBIAN

1 BASEMENT GNEISS COMPLEX
(GRENVILLE OROGEN)

Leucocratic to melanocratic gneiss; some quartz-rich gneiss, pelitic gneiss and schist and amphibolite; minor calc-silicate gneiss

9 Undivided ST. GEORGE GROUP and TABLE HEAD FORMATION

TRANSPORTED ROCKS
(CAMBRIAN TO MIDDLE ORDOVICIAN)

7 ST. ANTHONY COMPLEX

Brown weathering ultramafites, foliated amphibolite and gabbro, greenschist, greywacke and psammitic schist, schistose agglomerates and mafic pillow lavas

6 HUMBER ARM GROUP

Greyish green and grey sandstones and conglomerates, grey shale, minor grey limestone; rare lenses of limestone breccia of Cow Head types; rare, black, graptolite-bearing slaty shales; in some areas altered to slates and quartzitic sandstone

5 COW HEAD BRECCIA: Chaotic megabreccia, shingle breccia, common breccia; all with fragments of limestones of great variety; rare sandstone, chert, argillite, and previous breccias in matrix of limestone, and, rarely, sandstone as rare interbeds in other formations

4 MAIDEN POINT FORMATION: coarse grained greywacke; red, green, purple and black slate, quartz pebble conglomerate, minor limestone conglomerate, post-tectonic cordierite-andalusite hornfels; mafic agglomerate and tuff, massive basaltic flows, local pillow lava

Geology after - L. Cumming, I. Knight, R. Smyth, H. Williams.

SYMBOLS

geological boundary, defined, approximate, assumed

fault (including thrust fault), defined, approximate, assumed

NOLAN, WHITE & ASSOCIATES LTD.

DEPARTMENT OF CONSUMER AFFAIRS AND ENVIRONMENT
GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

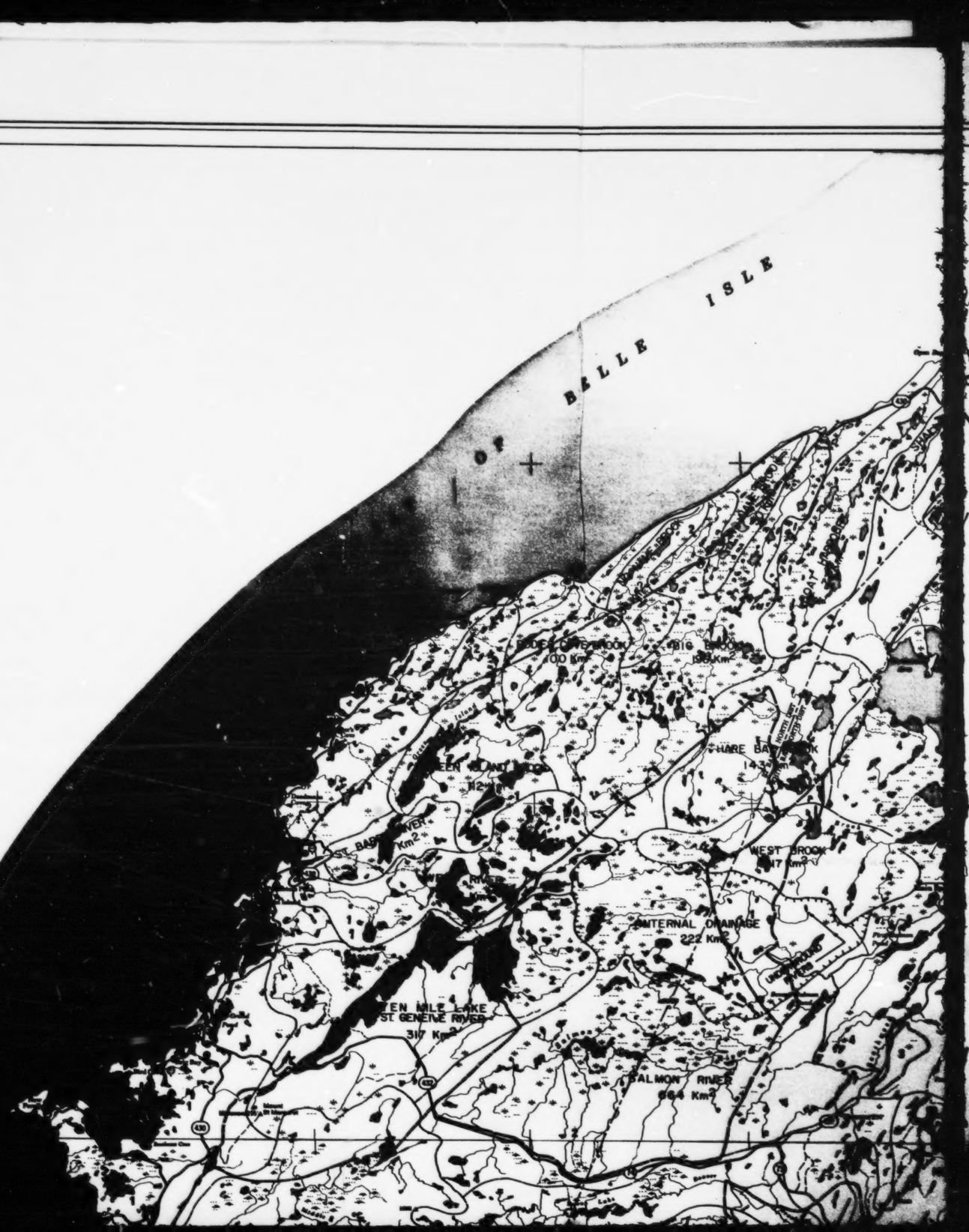
HYDROGEOLOGY

HYDROGEOLOGICAL STUDY - GREAT NORTHERN PENINSULA

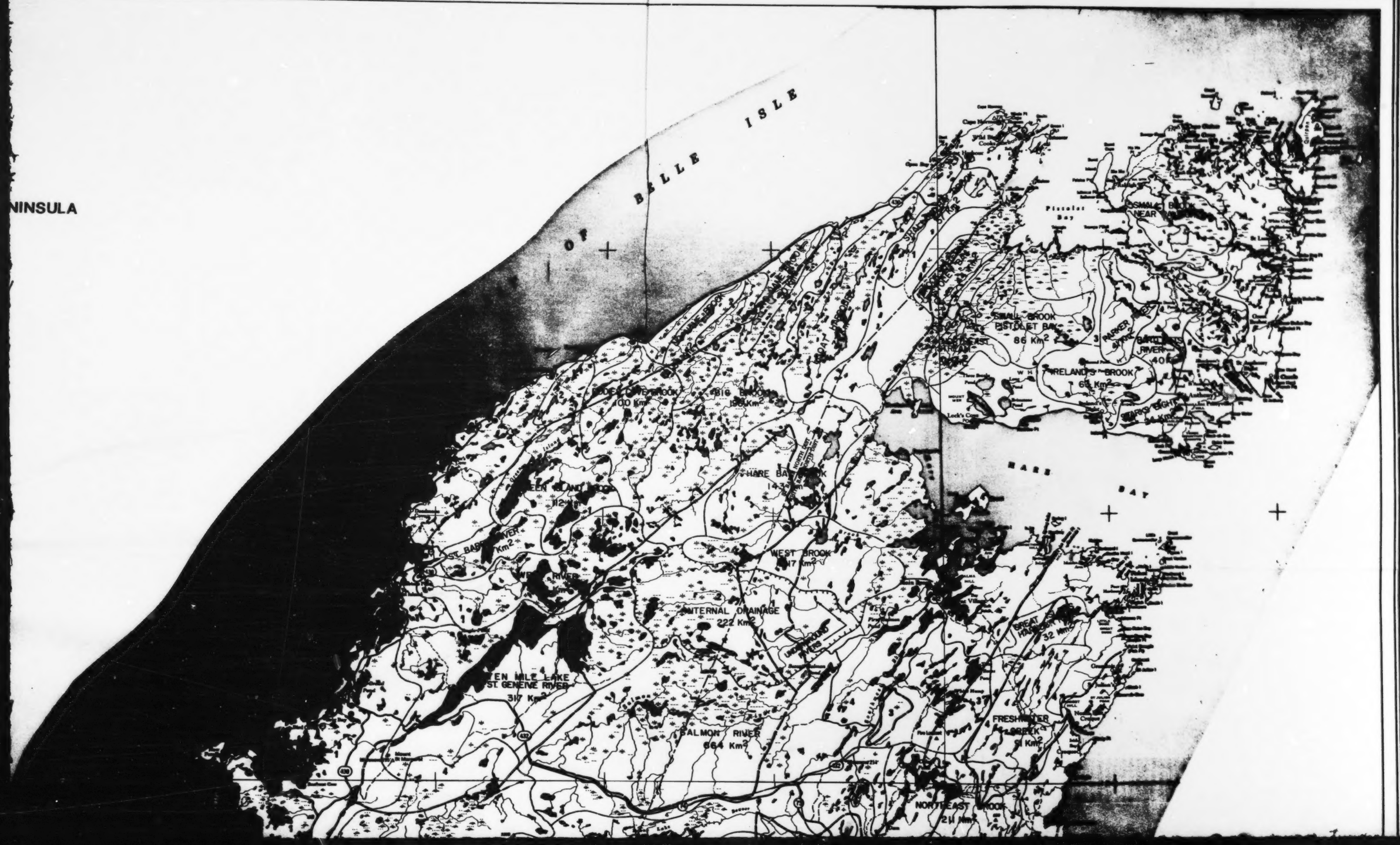
1979

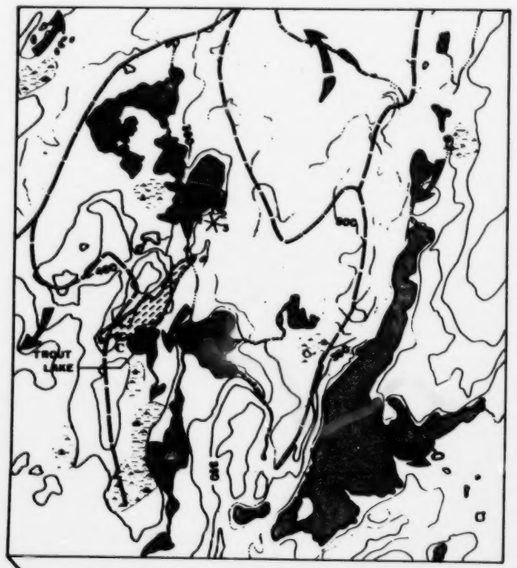
Map 3

Kilometres 5 0 5 10 15 20 25 30



NINSULA


OF BELLE ISLE
Pitcher's Pond
SMALL BROOK
PISTOLET BAY
86 Km²
PARKER BROOK
IRELAND'S BROOK
65 Km²
BARR'D ISLANDS
RIVER
40 Km²
BAY
HARE BAY BROOK
143 Km²
WEST BROOK
117 Km²
INTERNAL DRAINAGE
222 Km²
GREAT
32 Km²
EN MILE LAKE
ST GENEVE RIVER
317 Km²
SALMON RIVER
664 Km²
FRESHWATER
BROOK
NORTHEAST BROOK
21 Km²



NEWFOUNDLAND ZINC MINES PROPERTY
NEAR DANIELS HARBOUR
WATERSHED AND DRAINAGE PATTERN
— SCALE: 1 : 50,000 —

INTERNAL DRAINAGE
222 Km²
TEN MILE LAKE
ST GENEVE RIVER
317 Km²
SALMON RIVER
664 Km²
EASTERN RIVER
451 Km²
BEAVER BROOK
230 Km²
SHOAL BROOK
64 Km²
NORTHWEST BROOK
112 Km²
DOCTORS BROOK
BARRD HARBOUR
78 Km²
CLOUD BROOK
504 Km²
EAST RIVER
PORTUGAL COVE
93 Km²
TORRENT RIVER
810 Km²
RIVER OF PONDS

WEST BROOK
117 Km²

INTERNAL DRAINAGE
222 Km²

GREAT
32 Km²

TEN MILE LAKE
ST GENEIVE RIVER
317 Km²

SALMON RIVER
664 Km²

FRESHWATER
CREEK
Km²

NORTHEAST BROOK
211 Km²

BEAVER BROOK
330 Km²

SHOAL BROOK
64 Km²

NORTHWEST BROOK
112 Km²

DOCTORS BROOK
BARR'D HARBOUR
78 Km²

CLOUD BROOK
504 Km²

EAST RIVER
ROCKES BAY
93 Km²

TORRENT RIVER
510 Km²

NEWFOUNDLAND ZINC MINES PROPERTY
NEAR DANIELS HARBOUR
WATERSHED AND DRAINAGE PATTERN
— SCALE: 1 : 50,000 —

RIVER OF PONDS

PORTLAND CREEK
345 km²

PARSONS POND
263 km²

ST. PAULS RIVER INLET
315 km²

LEGEND

BEDROCK HYDROGEOLOGY & HYDROLOGICAL FEATURES

1

Average yield 70 L/min.
Well yield may vary considerably within this group throughout the Great Northern Peninsula.
Range in yield 2 to 182 L/min.
Consists of carbonate rocks of the St. George Group only.

2

Average yield 45 L/min.
Well yield may vary considerably within this formation throughout the Great Northern Peninsula.
Range in yield 0 to 230 L/min.
Dolomite, shale and quartzite of Forteau Formation.

3

Average yield 15 L/min.
This hydrostratigraphic unit consists of Maiden Point Formation, Humber Arm Group and St. Anthony Complex.

4

Wells in this unit yield less than 5 L/min.
Includes Table Head and Goose Tickle Formations; Anguile, Green Point and St. Pauls groups; Basement Gneiss Complex.
Few wells have been drilled in this unit and data is, therefore, lacking.

Drilled well - Municipal

Drilled well - Industrial

Drilled well - Private

Spring

Area of Internal Drainage

Watershed boundary

PORTLAND CREEK
945 km²
(PARSONS) POND
283 km²
ST PAULES RIVER / INLET
315 Km²
WESTERN BROOK POND
197 km²
GROS MORNE
BROOM
97 Km²
NATIONAL PARK

LEGEND

BEDROCK HYDROGEOLOGY & HYDROLOGICAL FEATURES

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Range in yield 2 to 182 L/min.
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Dolomite, shale and quartzite of Forteau Formation.

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This hydrostratigraphic unit consists of Maiden Point Formation, Humber Arm Group and St. Anthony Complex.

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Few wells have been drilled in this unit and data is, therefore, lacking.

Drilled well - Municipal

Drilled well - Industrial

Drilled well - Private

Spring

Area of Internal Drainage

Watershed boundary

Hydrostratigraphic boundary

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